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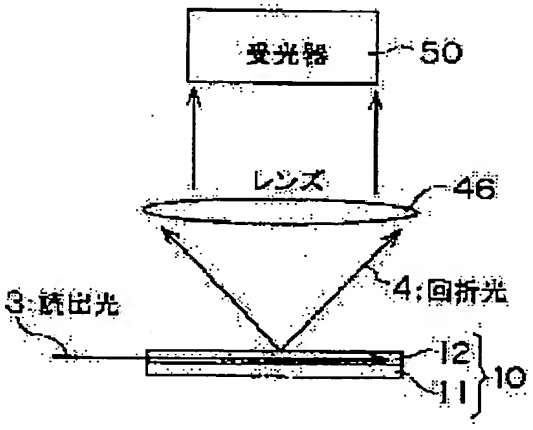
(54) OPTICAL RECORD MEDIUM, HOLOGRAM RECORD REPRODUCING METHOD, HOLOGRAM RECORD REPRODUCING DEVICE, OPTICAL RECORDER AND OPTICAL REPRODUCING DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a hologram record reproducing method or the like which makes it possible to record a hologram by which an ample diffraction efficiency is achieved and read out without breakage the hologram recorded through the guided wave of a readout beam which causes an incidence upon the recording layer from the end face.
SOLUTION: The light is subjected to the guided wave on the surface of a transparent substrate 11 at an incident angle greater than that of a determined value relative to this surface. A refractive index or an absorptive index is varied by the simultaneous irradiation of the signal beam and the reference beam each having a specified wavelength. The refractive index or the absorptive index varied is retained then an optical record medium 10 is used by which a recording layer 12 capable of recording the hologram is formed. When recorded, the hologram is recorded by simultaneously irradiating to the recording layer 12 the signal beam and the reference beam each having a prescribed wavelength. When reproduced, the recording layer 12 is subjected to the guided wave of a readout beam 3 of the wavelength which does not vary the refractive index or the absorptive index which is held by the recording layer 12. The hologram is reproduced by the diffracted light generated when the guided wave is forced to occur. This causes no problem with the guided wave loss upon being recorded. The recorded hologram can be reproduced without breakage upon being reproduced.



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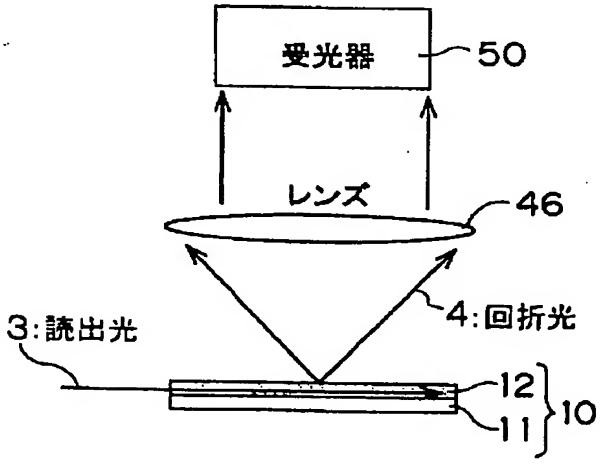
(54)【発明の名称】　光記録媒体、ホログラム記録再生方法、ホログラム記録再生装置、光記録装置、及び光再生装置

(57)【要約】
【課題】十分な回折効率が得られるホログラムを記録することができると共に、記録層に端面から入射させた読出光を導波させて、記録されたホログラムを破壊することなく読み出すことができるホログラム記録再生方法等を提供する。
【解決手段】透明基板１１の表面上に、この表面に対する入射角度が所定値以上の光を導波すると共に、所定波長の信号光及び参照光が同時に照射されることにより屈折率または吸収率が変化し、変化した屈折率または吸収率を保持してホログラムを記録が可能な記録層１２を形成した光記録媒体１０を用い、記録時には、記録層１２に所定波長の信号光及び参照光を同時に照射することによりホログラムを記録し、再生時には、記録層１２に保持された屈折率または吸収率を変化させない波長の読出光３を記録層１２に導波させ、導波させたときの回折光によりホログラムを再生する。これにより、記録時には導波損失が問題とならず、再生時には記録されたホログラムを破壊すること無く再生できる。



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【特許請求の範囲】

【請求項１】基板と、

該基板表面上に形成され、前記表面に対する入射角度が所定値以上の光を導波すると共に、所定波長の信号光及び参照光が同時に照射されることにより屈折率または吸収率が変化し、変化した屈折率または吸収率を保持してホログラムを記録可能な記録層と、

を含む光記録媒体。

【請求項２】前記記録層の屈折率が前記基板の屈折率より高い請求項１に記載の光記録媒体。

【請求項３】前記記録層上に形成され、該記録層より低い屈折率を有するクラッド層を更に含む請求項１または２に記載の光記録媒体。

【請求項４】前記記録層及び前記クラッド層を複数組積層した請求項１～３のいずれか１項に記載の光記録媒体。

【請求項５】前記記録層は、光誘起複屈折性を備えると共に側鎖に光異性化する基を有する高分子または高分子液晶から構成された請求項１～４のいずれか１項に記載の光記録媒体。

【請求項６】前記光異性化する基がアゾベンゼン骨格を含んでいる請求項５に記載の光記録媒体。

【請求項７】前記高分子または高分子液晶が、ポリエステル群から選ばれた少なくとも１種のモノマー重合体である請求項５または６に記載の光記録媒体。

【請求項８】請求項１～７のいずれか１項に記載の光記録媒体にホログラムを記録すると共に、記録されたホログラムを再生するホログラム記録再生方法であって、

記録時には、前記記録層に所定波長の信号光及び参照光を同時に照射することによりホログラムを記録し、

再生時には、記録層に保持された屈折率または吸収率を変化させない波長の読出光を前記記録層に導波させ、導波させたときの回折光によりホログラムを再生する、

ホログラム記録再生方法。

【請求項９】偏光分布によりデータ情報を保持する信号光を、参照光と同時に光記録媒体に照射し、該信号光の偏光分布をホログラムとして記録すると共に、読出光を前記記録層に導波させたときの回折光によりホログラムを再生する請求項８に記載のホログラム記録再生方法。

【請求項１０】前記データ情報に応じて前記信号光の偏光角を所定角度ずつ回転させることにより偏光分布させる請求項９に記載のホログラム記録再生方法。

【請求項１１】強度分布により第１のデータ情報を保持する信号光を、参照光と同時に光記録媒体の所定領域に照射し、該信号光の強度分布を第１のホログラムとして記録し、前記信号光及び前記参照光のいずれか一方の偏光状態を変えて、強度分布により第２のデータ情報を保持する信号光を、参照光と同時に光記録媒体の所定領域に照射し、該信号光の強度分布を第２のホログラムとして多重記録すると共に、読出光を前記記録層に導波させ

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たときの回折光により第１のホログラム及び第２のホログラムを再生する請求項８に記載のホログラム記録再生方法。

【請求項１２】請求項１～７のいずれか１項に記載の光記録媒体にホログラムを記録すると共に、記録されたホログラムを再生するホログラム記録再生装置であって、

前記記録層の所定領域に所定波長の信号光を記録層の導波方向と交差する方向から照射する信号光照射手段と、

前記信号光との干渉作用により記録層の屈折率または吸収率を変化させるように、前記所定領域に前記所定波長の参照光を照射する参照光照射手段と、

前記記録層に保持された屈折率または吸収率を変化させない波長の読出光を、該読出光が前記記録層を導波するように前記記録層に入射させる読出光入射手段と、

を備えたホログラム記録再生装置。

【請求項１３】記録層を備える光記録媒体であって、

前記記録層内を導波する読出光を入射させた場合に回折光を回折可能なホログラムを、前記記録層に記録可能な光記録媒体。

【請求項１４】記録層を備える光記録媒体であって、

前記記録層内を導波する読出光を入射させた場合に回折光を回折可能なホログラムが、前記記録層に記録されている光記録媒体。

【請求項１５】前記読出光は、前記記録層に記録不可能な光である請求項１３または１４記載の光記録媒体。

【請求項１６】前記ホログラムは、前記記録層の屈折率または吸収率の変化により記録され、前記読出光は、前記記録層の前記屈折率または前記吸収率の変化を誘起しない光である請求項１３または１４記載の光記録媒体。

【請求項１７】前記読出光は、シート状の前記記録層の端面から入射される請求項１３または１４記載の光記録媒体。

【請求項１８】光記録媒体の記録層にホログラムを記録する光記録装置であって、

前記記録層内を導波する読出光を入射させた場合に回折光を回折可能なホログラムを、前記記録層に記録する記録手段を備える光記録装置。

【請求項１９】ホログラムが記録された光記録媒体の記録層から回折光を回折させる光再生装置であって、

前記記録層内を導波する読出光を入射させて、前記記録層から前記回折光を回折させる読出手段を備える光再生装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、光記録媒体、ホログラム記録再生方法、ホログラム記録再生装置、光記録装置、及び光再生装置に関し、特に、３次元画像、２次元画像、またはデジタルデータページを記録できるホログラフィックメモリを構成する光記録媒体、ホログラム記録再生方法、ホログラム記録再生装置、光記録装置、

及び光再生装置に関する。

【０００２】

【従来の技術】ディジタル・ヴァーサタイル・ディスク（ＤＶＤ）等に代表される二次元光メモリは、大容量・高密度の記録媒体として使用されている。これら二次元光メモリの高密度化は、記録レーザ波長の短波長化と、ピックアップに使用する対物レンズの開口数（ＮＡ；Numerical Aperture）を大きくすることにより、データの記録・再生に用いるレーザスポットを小さくすることによって実現されてきた。そして、現在、青紫色レーザを光源とした二次元光メモリの研究開発が盛んに行われている。

【０００３】しかしながら、紫外領域では適当な光学材料が存在せず、記録メディア、レンズなどに使用する適当な光学材料が存在しなくなる等の理由から、記録レーザ波長の短波長化は、青紫色レーザの使用までが限界であり、これ以上短波長化することは困難であると考えられている。また、ＮＡを大きくする方法としては、屈折率の高い円形プリズムを用いて集光スポットを小さくする固体浸漬レンズ（ＳＩＬ：Solid Immersion Lens）を用いて、プリズムの屈折率倍だけ開口数を高くする方法が提案されている。この方法では、プリズム底面に形成されるエバネッセント光を利用して微小な集光スポットを形成する。エバネッセント光はプリズム底面（出射端）近傍に局在する非伝搬光であり、ＳＩＬの出射端から光の波長以下の領域内にしか存在しないため、記録媒体をプリズム底面の極近傍に配置して、記録及び再生を行わなければならない。このため、記録媒体とプリズムとの距離制御、記録媒体の可搬性の確立など解決すべき課題が多い。また、プリズム材料の屈折率は高々２程度であり、記録密度も４倍程度までしか向上しない。

【０００４】以上の理由から、現行の二次元光メモリでは、記録密度の向上は限界に達している。従って、５０ＧＢ以上の高密度の記録を行うためには、情報を記録媒体の奥行き方向を含めた三次元で記録（体積記録）する必要がある。

【０００５】情報をホログラムの形で記録するホログラフィックメモリは、三次元光メモリであり大容量での記録が可能である。また、ホログラフィックメモリは、ページ型メモリであり、２次元データのページ単位での一括記録・再生による高速性を併せ持つ。このため、ホログラフィックメモリは、次世代の記録媒体として注目されている。

【０００６】ホログラフィとは、光波の振幅（強度）と位相の情報を媒体に記録し、再生する技術である。レーザ光のようにコヒーレントな光を物体に照射し、物体からの反射光（物体光）を記録媒体に入射する際に、もう１本のコヒーレントな光（参照光）を同時に記録媒体に入射すると、記録媒体上に干渉縞が形成される。この干渉による光強度分布を屈折率または吸収率の変化として

媒体中に記録したものがホログラムである。ホログラムが記録された記録媒体に参照光のみを入射すると、ホログラムが回折格子として働き、物体光が再生される。

【０００７】また、ホログラフィックメモリでは、デジタルデータ（０または１の２値データ）を空間光変調器を用いてオン／オフ（明／暗）・パターンに変換し、物体光として記録媒体に入射させることにより、デジタルデータのホログラム記録も可能である。記録媒体に参照光を照射して物体光を再生し、再生した物体光をフォトディテクタで受光して光電変換することで、得られた電気信号から元の２値データを再生することができる。最近では、このデジタルホログラフィックメモリの具体的な光学系や体積多重記録方式に基づくＳ／Ｎやビット誤り率評価あるいは二次元符号化の提案、光学系の収差の影響など、より工学的な観点からの研究が進展している。

【０００８】ホログラム記録材料としては、安価でディスク状に成形容易なポリマー材料が注目されている。ＲＯＭ型の媒体用には、いわゆるフォトポリマーが盛んに研究されており、書き換え可能な媒体用には、アゾ基のような光異性化基を含む光感応性ポリマーが有望である。

【０００９】ホログラフィックメモリで大容量化を実現するためには、ホログラムを記録する記録層の厚みを増加すると共に、同一体積内に複数のホログラムを多重記録する必要がある。例えば１枚のディスクに１００ＧＢ以上のデジタルデータを蓄積するためには、記録層の厚みが１ｍｍ以上必要である。しかしながら、記録層を光学品質を維持しつつ厚膜化することは、現状では非常に困難であり且つコストがかかる。

【００１０】この問題を回避しつつ大容量化を実現した方法として、特開平９－１０１７３５号公報に記載された発明がある。特開平９－１０１７３５号公報には、多層構成の光導波路型の光記録媒体を用いた記録・再生方法が記載されている。この光記録媒体は、基板上に光導波層及び記録層をクラッド層を介して複数積層したものであり、隣接するクラッド層に挟まれた光導波層が光導波路を構成している。この光記録媒体を用いて、各光導波路に対して選択的に、光導波層の端面より参照光を入射させ、光導波層の界面より物体光（信号光）を入射させて、記録層へ浸み出したエバネッセント光と物体光とを干渉させてホログラムを記録する。この場合、ホログラムを１枚記録するのに要する記録層の厚みは数μｍと薄くて良く、スピンコートやキャスト法により光学品質を損なうことなく製膜することが可能である。このような薄膜の記録層を複数積層することで、多重ホログラム記録が可能となる。

【００１１】

【発明が解決しようとする課題】しかしながら、上述した特開平９－１０１７３５号公報に記載された多層構成

の光導波路型の光記録媒体を用いた記録・再生方法には、以下に示す問題点がある。この光記録媒体では、記録に用いる参照光を導波層に導波させ、記録層へ浸み出したエバネッセント光と物体光を干渉させてホログラムを記録するが、エバネッセント光は高々波長オーダーしか記録層に到達しないため、媒体厚み方向に十分な深さでホログラムを記録することができず、また、エバネッセント光は非常に微弱であるため、十分な露光強度が得られない。この結果、記録されたホログラムでは十分な回折効率が得られない。また、再生時にも十分な強度の読出光を照射することが困難である。

【００１２】これらの問題を解決するためには、記録層に参照光及び読出光を導波させ、エバネッセント光ではなく記録層を導波する参照光と物体光を干渉させてホログラムを記録し、記録層を導波する読出光によりホログラムを再生することが望まれる。しかしながら、記録層はホログラムを記録するために参照光を吸収する材料で構成されている。このため、記録層に端面より参照光を入射させて導波させたのでは、導波損失が大きくホログラムを記録することができない。また、通常、読出光には参照光と同じ波長の光が使用されるが、再生時に読出光を導波させたのでは、記録されたホログラムが破壊されてしまう。

【００１３】本発明は上記事情に鑑みなされたものであり、本発明の目的は、十分な回折効率が得られるホログラムを記録することができると共に、端面から入射された読出光が記録層を導波することができる光記録媒体を提供することにある。

【００１４】本発明の他の目的は、十分な回折効率が得られるホログラムを記録することができると共に、記録層に端面から入射させた読出光を導波させて、記録されたホログラムを破壊することなく読み出すことができるホログラム記録再生方法及びホログラム記録再生装置を提供することにある。

【００１５】本発明の更に他の目的は、十分な回折効率が得られるホログラムを記録することができる光記録装置と、記録層に端面から入射させた読出光を導波させて、記録されたホログラムを破壊することなく読み出すことができる光再生装置と、を提供することにある。

【００１６】

【課題を解決するための手段】上記目的を達成するために、本発明の第１の光記録媒体は、基板と、該基板表面上に形成され、前記表面に対する入射角度が所定値以上の光を導波すると共に、所定波長の信号光及び参照光が同時に照射されることにより屈折率または吸収率が変化し、変化した屈折率または吸収率を保持してホログラムを記録可能な記録層と、を含んで構成したことを特徴とする。

【００１７】本発明の第１の光記録媒体は、基板表面上に所定波長の信号光及び参照光が同時に照射されることにより屈折率または吸収率が変化し、変化した屈折率または吸収率を保持してホログラムを記録可能な記録層が形成されているが、この記録層は基板表面に対する入射角度が所定値以上の光を導波するので、再生時に記録層に読出光を導波させることができ、導波させたときの回折光によりホログラムを再生することができる。

【００１８】上記の第１の光記録媒体においては、前記記録層の屈折率を前記基板の屈折率より高くすることにより、記録層がスラブ型光導波路となり、記録層に所定値以上の入射角度で入射された光を導波することができる。また、前記記録層上に該記録層より低い屈折率を有するクラッド層を更に形成することができる。更に、前記記録層及び前記クラッド層を複数組積層して、複数の記録層を備えた多層構成の光記録媒体とすることもできる。

【００１９】光誘起複屈折性（光誘起２色性または光誘起異方性とも呼ばれる）を示す材料は、これに入射する光の偏光状態に感応し、入射光の偏光方向を記録することができる。この中でも、側鎖に光異性化する基を有する高分子または高分子液晶は記録特性に優れている。従って、光記録媒体としては、光誘起複屈折性を備えると共に側鎖に光異性化する基を有する高分子または高分子液晶からなる記録層を設けたものが好ましい。光異性化する基としては、アゾベンゼン骨格を含むものが好ましく、高分子または高分子液晶としては、ポリエステル群から選ばれた少なくとも１種のモノマー重合体が好ましい。

【００２０】本発明の第２の光記録媒体は、記録層を備えており、該記録層内を導波する読出光を入射させた場合に回折光を回折可能なホログラムを前記記録層に記録することができる。そして、この光記録媒体にホログラムを記録することにより、記録層内を導波する読出光を入射させた場合に回折光を回折可能なホログラムが記録層に記録された光記録媒体を得ることができる。

【００２１】本発明の第２の光記録媒体において、記録層内を導波する読出光を入射させた場合に記録されたホログラムから回折光を十分な回折効率で得るために、記録層に記録不可能な読出光を使用することができる。例えば、ホログラムが記録層の屈折率または吸収率の変化により記録されている場合には、読出光には記録層の屈折率または吸収率の変化を誘起しない光を使用することができる。

【００２２】また、読出光をシート状の記録層の端面から入射させることにより、読出光を記録層に導波させることができる。

【００２３】本発明のホログラム記録再生方法は、本発明の光記録媒体にホログラムを記録すると共に、記録されたホログラムを再生するホログラム記録再生方法であって、記録時には、前記記録層に所定波長の信号光及び参照光を同時に照射することによりホログラムを記録

し、再生時には、記録層に保持された屈折率または吸収率を変化させない波長の読出光を前記記録層に導波させ、導波させたときの回折光によりホログラムを再生することを特徴とする。

【００２４】本発明のホログラム記録再生装置は、本発明の光記録媒体にホログラムを記録すると共に、記録されたホログラムを再生するホログラム記録再生装置であって、前記記録層の所定領域に所定波長の信号光を記録層の導波方向と交差する方向から照射する信号光照射手段と、前記信号光との干渉作用により記録層の屈折率または吸収率を変化させるように、前記所定領域に前記所定波長の参照光を照射する参照光照射手段と、前記記録層に保持された屈折率または吸収率を変化させない波長の読出光を、該読出光が前記記録層を導波するように前記記録層に入射させる読出光入射手段と、を備えたことを特徴とする。

【００２５】本発明のホログラム記録再生方法及びホログラム記録再生装置では、記録時には、記録層に所定波長の信号光及び参照光を同時に照射することによりホログラムを記録するが、再生時には、記録層に保持された屈折率または吸収率を変化させない波長の読出光を記録層に導波させ、導波させたときの回折光によりホログラムを再生するので、記録時には導波損失が問題とならず、再生時には記録されたホログラムを破壊すること無く再生することができる。

【００２６】上記のホログラム記録再生方法を適用して、偏光分布によりデータ情報を保持する信号光を、参照光と同時に光記録媒体に照射し、該信号光の偏光分布をホログラムとして記録すると共に、読出光を前記記録層に導波させたときの回折光によりホログラムを再生することができる。この偏光ホログラムは、その回折光として信号光の偏光方向が保存された光を発生させるので、例えば、データ情報に応じて信号光の偏光角を所定角度ずつ回転させて偏光分布させることにより、偏向角の違いによる情報の読み出しが可能になる。

【００２７】また、上記のホログラム記録再生方法を適用して、強度分布により第１のデータ情報を保持する信号光を、参照光と同時に光記録媒体の所定領域に照射し、該信号光の強度分布を第１のホログラムとして記録し、前記信号光及び前記参照光のいずれか一方の偏光状態を変えて、強度分布により第２のデータ情報を保持する信号光を、参照光と同時に光記録媒体の所定領域に照射し、該信号光の強度分布を第２のホログラムとして多重記録すると共に、読出光を前記記録層に導波させたときの回折光により第１のホログラム及び第２のホログラムを再生することができる。

【００２８】この異なる偏光方向を有する２つの信号光が同一の参照光によって同一領域に記録されている光記録媒体の前記領域に、読出光を照射して、互いに直交する偏光方向を有する２つの回折光成分が合成された回折光を得、この回折光から任意の偏光成分を取り出すことによって、前記領域に２つの信号光として記録されている２つのデータ間の演算出力を得ることができる。即ち、光記録媒体に記録されている２つの画像などのデータ間で、和または差の演算や論理演算などの任意の演算を、簡便かつ高速に行うことができる。

【００２９】なお、ホログラム記録再生装置は、光記録媒体の記録層にホログラムを記録する光記録装置と、ホログラムが記録された光記録媒体の記録層から回折光を回折させる光再生装置と、から構成することができる。光記録装置と光再生装置とは一体に構成してもよく、各々別々に構成してもよい。

【００３０】本発明の光記録装置は、光記録媒体の記録層にホログラムを記録する光記録装置であって、前記記録層内を導波する読出光を入射させた場合に回折光を回折可能なホログラムを前記記録層に記録する記録手段を備えることを特徴とする。また、本発明の光再生装置は、ホログラムが記録された光記録媒体の記録層から回折光を回折させる光再生装置であって、前記記録層内を導波する読出光を入射させて、前記記録層から前記回折光を回折させる読出手段を備えることを特徴とする。即ち、本発明の光記録装置は、十分な回折効率が得られるホログラムを記録することができ、本発明の光再生装置は、記録層に端面から入射させた読出光を導波させて、記録されたホログラムを破壊することなく読み出すことができる。

【００３１】

【発明の実施の形態】以下、図面を参照して本発明の実施の形態について説明する。

（ホログラム光記録媒体）まず、本発明の光記録媒体について説明する。

【００３２】図１（Ａ）に示すように、光記録媒体１０は、石英基板やプラスチック基板などの透明基板１１の一面側にホログラムを記録可能な記録層１２を形成して構成されている。ここで、再生時に読出光として照射するレーザ波長においては、記録層１２の屈折率n_1は透明基板１１の屈折率n_2よりも高く、記録層１２がスラブ型光導波路となる。また、記録層１２の屈折率n_1は空気層の屈折率よりも高い。なお、記録時の信号光（物体光）１および参照光２は、図示するように透明基板１１側から照射する。

【００３３】また、図１（Ｂ）に示すように、複数組の記録層１２及びクラッド層１３を交互に積層してスラブ型導波路を複数作製し、多層構成の光導波路型の光記録媒体とすることもできる。クラッド層１３の屈折率は、透明基板１１の屈折率と同じn_2とすることができる。

【００３４】図１（Ａ）及び（Ｂ）のいずれの場合においても、記録層１２はシート状に、すなわち厚みに比べて十分大きな拡がりを有するように形成する。好ましくは、光記録媒体１０を全体としてシート状に形成する。

また、光記録媒体１０はディスク形状あるいはカード形状とするのが好ましい。

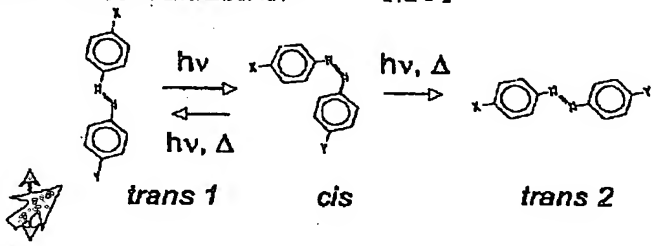
【００３５】記録層１２は、屈折率または吸収率が変化してホログラムを記録することが可能であり、変化した屈折率または吸収率が常温で保持される材料であれば、どのような材料で構成されていてもよい。好適な材料としては、光誘起複屈折性を示す光感応性の材料が挙げられる。光誘起複屈折性を示す材料は、入射する光の偏光状態に感応し、入射光の偏光方向を記録することができる。なお、偏光分布に対応した光誘起複屈折によるホログラムを記録することができる光記録媒体を、偏光感応型の光記録媒体と称する。

【００３６】光誘起複屈折性を示す材料としては、側鎖に光異性化する基を有する高分子または高分子液晶、または光異性化する分子を分散させた高分子が特に好適である。また、光異性化する基または分子としては、例えば、アゾベンゼン骨格を含むものが好適である。

【００３７】ここで、アゾベンゼンを例に光誘起複屈折＊の原理について説明する。アゾベンゼンは、下記化学式に示すように、光の照射によってトランスーシスの光異性化を示す。光記録層に光照射する前は、光記録層にはトランス体のアゾベンゼンが多く存在する。これらの分子はランダムに配向しており、マクロに見て等方的である。光記録層に矢印で示す所定方向から直線偏光を照射すると、その偏光方位と同じ方位に吸収軸を持つトランス１体は選択的にシス体に光異性化される。偏光方位と直交した吸収軸を持つトランス２体に緩和した分子は、もはや光を吸収せずその状態に固定される。結果として、マクロに見て吸収係数及び屈折率の異方性、つまり二色性と複屈折が誘起される。一般に、これらの性質は、光誘起複屈折性、光誘起２色性、または光誘起異方性と呼ばれている。また、円偏光または無偏光の光を照射することによって、これら励起された異方性を消去することができる。

【００３８】

【化１】

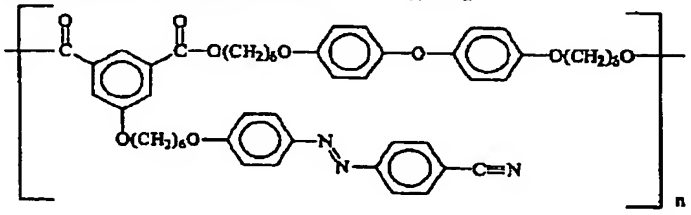


【００３９】このような光異性化基を含む高分子は、光異性化により高分子自身の配向も変化し大きな複屈折を誘起することができる。このように誘起された複屈折は高分子のガラス転移温度以下で安定であり、ホログラムの記録に好適である。

【００４０】記録層１２を構成する材料の好適な例として、下記の化学式で表される側鎖にシアノアゾベンゼンを有するポリエステルを挙げることができる。このポリエステルは、側鎖のシアノアゾベンゼンの光異性化による※光誘起異方性に起因して、信号光の強度及び偏光方向をホログラムとして記録できる（"Holographic recording and retrieval of polarized light by use of polyester containing cyanoazobenzene units in the side chain", K. Kawano, T. Ishii, J. Minabe, T. Niitsu, Y. Nishikata and K. Baba, Opt. Lett. Vol. 24 (1999) pp. 1269-1271）。

【００４１】

【化２】



【００４２】上記のポリエステル材料からなる記録層１２を備えた光記録媒体１０は、ポリエステルのクロロホルム溶液を洗浄したガラス基板上にキャストし乾燥させることによって作製することができる。膜厚２０μｍの記録層１２が形成された光記録媒体１０の吸収スペクトルを測定したところ、アゾベンゼンのπ－π＊遷移に相当する３６５ｎｍ付近にピークを有するスペクトルが得られた。

【００４３】なお、光記録媒体の作製方法はこれに限られるものではなく、記録層の材料を基板上にスピンコートして光記録媒体を作製してもよく、記録層の材料を平行平板セルへ注入して光記録媒体を作製してもよい。また、フィルム状基板に記録層の材料をホットプレスにより接着して光記録媒体を作製してもよい。

【００４４】（偏光ホログラム記録の原理）このアゾベンゼンを側鎖に有する高分子または高分子液晶、またはアゾベンゼンを分散させた高分子からなる記録層１２を備える光記録媒体１０に、ホログラムを記録する場合、それぞれコヒーレントな信号光１および参照光２を、光記録媒体１０の同一領域に同時に照射する。

【００４５】この場合、信号光１と参照光２の偏光方向が互いに平行なとき、例えば、図２（Ａ）に示すように、信号光１と参照光２がともにｓ偏光のときには、光記録媒体１０中に、信号光１と参照光２の２光波干渉により光強度分布を生じる。そして、光強度の強いところでは、前述したように、トランスーシスートランスの異性化サイクルによって光学異方性が誘起される。従って、光強度分布に対応した吸収率または屈折率の格子がホログラムとして記録される。

【００４６】これに対して、信号光１と参照光２の偏光方向を互いに直交させたとき、例えば、図２（Ｂ）に示すように、信号光１をｐ偏光とし、参照光２をｓ偏光としたときには、信号光１と参照光２の偏光方向が互いに平行なときのような光強度分布は生じない。その代わりに、偏光方向が空間的・周期的に変調され、直線偏光部分８と楕円偏光部分９が交互に周期的に現れる。

【００４７】この場合、光強度分布は一様となるが、変調された偏光方向と同一の方向を向くアゾベンゼンが、前述したように、トランスーシスートランスの異性化サイクルによって光学異方性が誘起され、ホログラムとして記録される。

【００４８】以後、図２（Ａ）のように信号光１と参照光２の偏光方向が平行なときの光強度分布によるホログラムを光強度ホログラムと称し、図２（Ｂ）のように信号光１と参照光２の偏光方向が直交するときの偏光分布によるホログラムを偏光ホログラムと称する。

【００４９】このように、アゾベンゼンを側鎖に有する高分子または高分子液晶、またはアゾベンゼンを分散させた高分子からなる記録層１２を備える光記録媒体１０によれば、信号光１と参照光２の偏光方向が平行であっても直交していても、アゾベンゼンの異方性が誘起される結果、ホログラムを記録することができる。

【００５０】上記の各々の場合にホログラム読出光３の偏光方向を参照光２の偏光方向と同じ方向とすれば、信号光１と同じ偏光状態を持つ回折光４を得ることができる。また、記録されたホログラムは室温自然光のもとで数年以上緩和なく保持される。

【００５１】（ホログラム記録再生装置）図３に本発明のホログラム記録再生装置の一例を示す。このホログラム記録再生装置は、図３（Ａ）に示す記録装置、及び図３（Ｂ）に示す再生装置から構成されている。記録装置と再生装置とは一体に構成してもよく、各々別々に構成してもよい。

【００５２】記録装置は、図３（Ａ）に示すように、光記録媒体１０の所定領域に信号光１及び参照光２を同時に照射してホログラムを記録する記録ヘッド２２を備えている。記録ヘッド２２は、コヒーレントな光を発する光源４０、光源４０からの光を信号光用及び参照光用の二光波に分けるビームスプリッタ４１、ビームスプリッタ４１を透過した光波を平行光化するレンズ４３及び４４、平行光化された光波を変調する空間光変調器３０、変調された信号光１を光記録媒体１０の所定領域に集光する集光レンズ４５、及びビームスプリッタ４１で反射された光波を参照光２として光記録媒体１０の所定領域に導くミラー４７、４８を備えている。なお、空間光変調器３０はコンピュータ２１に接続され、コンピュータ２１により制御されている。

【００５３】記録ヘッド２２の光源４０としては、光記録媒体１０の記録層１２の材料に感度があり、且つコヒーレントな光を発するものを使用することができる。側鎖にシアノアゾベンゼンを有するポリエステルを記録層１２に用いる場合には、光記録媒体１０の吸収ピークの裾に対応する発振波長５１５ｎｍのアルゴンイオンレーザを光源に使用するのが好ましい。

【００５４】空間光変調器３０としては、液晶等の電気光学変換材料の両面に透明電極を形成した透過型の空間光変調器を用いることができる。このタイプの空間光変調器としては、プロジェクタ用の液晶パネルを挙げることができる。

【００５５】但し、偏光変調を可能にするためには、上記のプロジェクタ用の液晶パネルを用いる場合には、少なくとも出力側に配置された偏光板を取り除く必要がある。例えば、空間光変調器３０は、図４に示すように、電気光学変換部材の一つである液晶１２１の両面に電極１２２、１２３を形成した透過型の液晶セル１２４として構成することができる。この偏光変調を行う空間光変調器では、２次元的に複数の画素を形成して、それぞれの画素を１／２波長板として機能させ、それぞれの画素に２次元データの対応するビットの情報を電圧印加の有無として与えることにより、それぞれの画素に入射する光の偏光を変調する。

【００５６】再生装置は、図３（Ｂ）に示すように、コヒーレントな光を光記録媒体１０の端面から入射させるための読出し光学系３１と、記録されたホログラムによる回折光４を読み取る読取り部２３と、を備えている。読取り部２３は、回折光４を平行光化するレンズ４６、及び入射される回折光を検出するＣＣＤ等の光検出器５０を備えている。

【００５７】読出し光学系３１は、光記録媒体１０の記録層１２に記録されたホログラムが保持する屈折率または吸収率を変化させず（即ち、記録されたホログラムを破壊することなく）、且つコヒーレントな光を発する光源を含んで構成することができる。側鎖にシアノアゾベンゼンを有するポリエステルを記録層１２に用いる場合

には、光記録媒体１０の記録層１２に感度の無い（吸収の無い）発振波長６３３ｎｍのヘリウムネオンレーザを光源として使用するのが好ましいが、それ以外のレーザダイオードを用いても良い。

【００５８】（ホログラム記録再生方法）次に、本発明のホログラム記録再生方法を説明する。

【００５９】まず、記録時には、図３（Ａ）に示す記録装置において、記録ヘッド２２の光源４０から出力されたコヒーレント光は、ビームスプリッタ４１により信号光用及び参照光用の二光波に分けられる。ビームスプリッタ４１を透過した光波はレンズ４３および４４により光径の大きな平行光とされる。その後、平行光化された光波は、空間光変調器３０により変調されて信号光１が生成される。

【００６０】変調された信号光１は、レンズ４５により縮小またはフーリエ変換されて、光記録媒体１０の所定領域に照射される。一方、ビームスプリッタ４１で反射された参照光２は、ミラー４７及び４８で反射されて光記録媒体１０の所定領域に導かれ、光記録媒体中で信号光１と交差するように光記録媒体１０に入射される。このように信号光１と参照光２とを同一領域に同時に照射することによりホログラム記録を行う。

【００６１】上述した通り、信号光１及び参照光２としては、光記録媒体１０の記録層１２の材料に感度がある波長のレーザ光を用いる。また、信号光１及び参照光２の入射角度は以下のように求めることができる。

【００６２】図６に示すように、記録時の信号光１及び参照光２の波数ベクトルをそれぞれk_{object}及び$k_{reference}$とし、読出光３の波数ベクトルをk_{read}とすると、読出光３のベクトル方向を基準にして、k_{object}及び$k_{reference}$はそれぞれ角度がα及びβであり、二光波の交差角は$\alpha-\beta$である。k_{object}及び$k_{reference}$によって形成される格子ベクトルは、$k_g = k_{object} - k_{reference}$で与えられ、記録されたホログラムの格子間隔$\Lambda$は、下記式１で与えられる。

【００６３】

【数１】

$$\Lambda = \frac{\lambda}{2\sin\left(\frac{\alpha-\beta}{2}\right)}$$

式１

【００６４】ここで、記録に用いた信号光及び参照光の波長をλとし、波長λ'の読出光（波数ベクトルk_{read}）が基板面に対し角度０で入射する場合を考える。このとき格子への入射角度は（$\alpha+\beta$）／２であり、下記式２の位相整合条件を満たす場合に強い回折光を得る。

【００６５】

【数２】

$$\sin\left(\frac{\alpha+\beta}{2}\right) = m\frac{\lambda'}{2\Lambda} \quad (n=1,2,3,\cdots)$$

式２

【００６６】式２は多重反射による各層からの反射光が同位相になる条件であるから、式１と式２とにより式３の関係が導かれる。

【００６７】

【数３】

$$m\frac{\lambda'}{\lambda} = \frac{\sin\left(\frac{\alpha+\beta}{2}\right)}{\sin\left(\frac{\alpha-\beta}{2}\right)}$$

式３

【００６８】式３を満たすようなαとβであれば、読出光が導波路を導波したときに、ホログラムの位相整合条件を満たし、回折光を得ることができる。回折光が導波路に対して垂直に出射する条件は、格子への入射角度（$\alpha+\beta$）／２＝４５°の場合である。この条件を式３に代入すると、各々式４及び式５で表されたα及びβが求められる。即ち、信号光の入射角度α及び参照光の入射角度βは、信号光及び参照光の波長λ及び読出光の波長λ'が決まれば、その値に応じて算出することができる。

【００６９】

【数４】

$$\beta = 45 - \sin^{-1}\left(\frac{\sqrt{2}}{2m}\frac{\lambda}{\lambda'}\right)$$

式４

$$\alpha = 45 + \sin^{-1}\left(\frac{\sqrt{2}}{2m}\frac{\lambda}{\lambda'}\right)$$

式５

【００７０】例えば、λ＝５１５ｎｍ、λ'＝６３３ｎｍ、ｍ＝１として、αおよびβを求めると、信号光の入射角度α＝８０°、参照光の入射角度β＝１０°と算出できる。

【００７１】次に、読み出し時に、図３（Ｂ）に示す再生装置において、読出し光学系３１から出力されたコヒーレント光は、読出光３として光記録媒体１０の記録層１２の端面から入射される。図８に示すように、入射された読出光３は記録層１２を導波し、回折光が記録層１２から回折される。回折された光波（回折光４）は、これをレンズ４６により光検出器５０に結像させる。

【００７２】上述した通り、読出光３としては、光記録媒体１０の記録層１２に記録されたホログラムが保持する屈折率または吸収率を変化させない波長のレーザ光、例えば、光記録媒体１０の記録層１２の材料に感度が無い波長のレーザ光を用いる。このように、再生時に光記

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録媒体１０の記録層１２に記録されたホログラムが保持する屈折率または吸収率を変化させない波長のレーザ光を読出光３として用いることにより、読出光３を記録層１２に導波させて、記録されたホログラムを破壊すること無く再生することができる。

【００７３】また、読出光３が記録層１２を導波するので、読出光３の導波路に沿って記録されたホログラムを一度に読み出すことができる。

【００７４】なお、図５に示すように、空間変調器３０で変調された信号光１を、レンズを介さずに光記録媒体１０に入射させてホログラム記録を行った場合には、図９に示すように、記録に用いた参照光２の入射方向と反対の方向から読出光３を記録層１２に導波させてホログラムを読み出すこともできる。この場合、参照光２の波長と読出光３の波長は異なるので倍率及び光路は変化するが、回折光４として信号光１の位相共役光を再生することができる。位相共役光は、信号光と同一波面を備えており、信号光が入射した光路を逆進する。そのため、特別な結像光学系を用いることなく光検出器５０に結像することができる。この場合、光記録媒体１０の端面から読出光３を入射して、信号光１の入射側から回折光４を取り出すことになる。

【００７５】また、参照光２を光記録層１２に例えば１０°といった狭い角度で入射させるためには、例えば、図７に示すように、透明基板１１と同じ屈折率の厚手のガラス基板１４を、光記録媒体１０の透明基板１１側に接触させ、このガラス基板１４の側面から参照光２を入射させればよい。ガラス基板１４の側面から入射された参照光２は、空気とガラス基板１４との界面で屈折し、ガラス基板１４への入射角度より狭い角度で光記録層１２に入射する。また、透明基板１１を十分厚くして、透明基板１１の側面から参照光２を入射させてもよい。

【００７６】（偏光ホログラム記録）上記のホログラム記録再生方法を用いて偏光ホログラム記録を行う例について説明する。前記した側鎖にシアノアゾベンゼンを有するポリエステルからなる記録層を備えた偏光感応型の光記録媒体を用いて、図３（Ａ）及び（Ｂ）に示すホログラム記録再生装置により記録及び再生を行った。

【００７７】記録用の光源４０には、記録層の材料であるポリエステルに感度のある発振波長５１５ｎｍのアルゴンイオンレーザを用い、信号光と参照光との交差角φは７０°とした。偏光変調型の空間光変調器３０を用いて、図１０に示す偏光分布を持つ信号光を生成した。この信号光では、各画素毎に直線偏光の方位が変化しており偏光方位がデータ情報を表している。ここで、Ｎ値の方位を記録するようにすると、各画素毎に$\log_2 N$ビットのデータが蓄積できる。

【００７８】また、読出光学系３０の光源には、記録層の材料であるポリエステルに感度の無い発振波長６３３ｎｍのヘリウムネオンレーザを用いた。但し、記録に用

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いた参照光の入射方向と対向する方向から読出光を記録層に導波させて、信号光の位相共役光を回折させた。回折光の光路に検光子を配置し、直交する偏光成分（０°偏光成分と９０°偏光成分）に分離した。その結果、図１１（Ａ）及び（Ｂ）に示すような０°偏光成分と９０°偏光成分の二画像を得た。これら二画像間の光強度分布比より、下記式６を用いて再生光の偏光角ρを算出した。

【００７９】

【数５】

$$\rho = \tan^{-1}\left(\sqrt{\frac{I_{90}}{I_0}}\right)$$

式６

【００８０】ここで、I_0とI_{90}は、それぞれ各画素の０°偏光成分及び９０°偏光成分の強度である。得られた再生像の偏光角を信号光の偏光角に対してプロットした結果を図１２に示す。図１２より、再生像の偏光角は信号光の偏光角に対して略直線的に変化しており、信号光の偏光方位と再生光の偏光方位とが同じであることが分かる。従って、本発明のホログラム記録再生方法によれば、信号光の偏光分布を記録することができると共に、記録された偏光分布を忠実に再生することができる。

【００８１】なお、上記では偏光分布によりデータ情報を保持する信号光を用いて、ホログラムの記録及び再生を行う例について説明したが、振幅（強度）分布や位相分布によってデータ情報を保持する信号光についても、同様にホログラムの記録及び再生を行うことができる。例えば、３次元物体からの反射光を信号光として記録することにより、立体像の再生も可能である。

【００８２】（偏光ホログラム多重記録）次に、上記のホログラム記録再生方法を用いて、信号光と参照光の偏光方向が互いに平行である場合と直交する場合の２つの条件で２重にホログラム記録を行う例、即ち、第１段階で信号光と参照光の偏光方向を平行にしてホログラム記録を行い、第２段階で信号光（あるいは参照光）の偏光方向を１／２波長板によって９０°回転させて、信号光と参照光の偏光方向を互いに直交させた条件で、２枚目のホログラムを同一領域に多重記録する例について説明する。ただし、互いに直交する円偏光を用いても、同様の偏光多重記録・再生は可能である。

【００８３】前記した側鎖にシアノアゾベンゼンを有するポリエステルからなる記録層１２を備えた偏光感応型の光記録媒体１０を用いて、図１３（Ａ）に示すように、空間変調器３０と光記録媒体１０との間に１／２波長板２０を配置した以外は、図７に示す記録装置と同じ構成とし、図１３（Ｂ）に示すように、光記録媒体１０と光検出器５０との間に、回折光４に含まれる所定の偏光成分を分離する偏光ビームスプリッタ等の偏光子４９

を配置した以外は、図９に示す再生装置と同じ構成として、ホログラムの記録及び再生を行った。

【００８４】図１３（Ａ）に示すように、後述するように、図示しないコンピュータによって空間光変調器３０に画像を表示して、空間光変調器３０を通過した光として、空間光変調器３０に表示された画像の情報を有する信号光を得、この信号光を１／２波長板２０を通過させて、所定の偏光方向を有する信号光１に変換する。この１／２波長板２０を通過した信号光１を上述した光記録媒体１０に照射する。同時に、参照光２を光記録媒体１０の信号光１が照射される領域に照射する。これによって、光記録媒体１０中で信号光１と参照光２とが干渉して、光記録媒体１０中にホログラムが記録される。

【００８５】この場合、第１段階では、１枚目の画像として、図１４（Ａ）に示したような２値強度画像を空間光変調器３０に表示し、１／２波長板２０を、これを通過した信号光１の偏光方向が紙面に垂直（これを０°とする）となるように調整して、信号光１と参照光２を同時に光記録媒体１０に照射することによって、光記録媒体１０中に１枚目のホログラムを記録する。

【００８６】次に、第２段階では、２枚目の画像として、図１４（Ｂ）に示したような２値強度画像を空間光変調器３０に表示し、１／２波長板２０を、これを通過した信号光１の偏光方向が紙面に平行（これを９０°とする）となるように調整して、信号光１と参照光２を同時に光記録媒体１０に照射することによって、光記録媒体１０中の１枚目のホログラムが記録された領域に２枚目のホログラムを記録する。ただし、参照光２の偏光方向は、１枚目のホログラムの記録時と２枚目のホログラムの記録時で同一にする。

【００８７】読み出し時には、図１３（Ｂ）に示すように、読出し光学系３１から出力されたコヒーレント光は、読出光３として光記録媒体１０の記録層１２の端面から入射される。入射された読出光３は記録層１２を導波し、２次回折光が記録層１２から回折される。

【００８８】その回折光４を、ＣＣＤなどの光検出器５０上に結像させて、信号光１のデータ画像を読み取る。即ち、第１段階および第２段階で記録された２枚のホログラムからの再生像を得ることができる。但し、２枚のホログラムからの回折光の各々は、偏光方向が互いに直交している。この場合、光記録媒体１０と光検出器５０との間に偏光子４９を配置し、図示しないコンピュータによって、この偏光子４９の透過軸を任意の方向に調整することによって、２つの回折像を分離して読み出すことができる。例えば、以下のように、１枚目の画像または２枚目の画像のみ、または１枚目の画像と２枚目の画像との間の任意の演算出力を、読み出すことができる。

【００８９】図１５に示すように、１枚目の画像のみを読み出すときには、偏光子４９の透過軸を０°とし、２枚目の画像のみを読み出すときには、偏光子４９の透過軸を９０°とする。第１段階で記録された１枚目のホログラムからの回折光成分A_1の振幅をT_1、第２段階で記録された２枚目のホログラムからの回折光成分A_2の振幅をT_2とすると、偏光子４９の透過軸を０°としたときには、偏光子４９を透過する光強度は$|T_1|^2$に比例し、偏光子４９の透過軸を９０°としたときには、偏光子４９を透過する光強度は$|T_2|^2$に比例する。

【００９０】但し、これは、信号光１の偏光が回折光４に忠実に再生された場合である。実際には、光学系や光記録媒体１０の偏光特性によって、回折光４の偏光方向は信号光１のそれと若干ずれる可能性がある。しかし、その場合でも、多重記録されている２つの画像の偏光方向は互いに直交した関係に保たれているので、偏光子４９の透過軸を適当に調整することによって、２つの画像をクロストークを生じることなく分離して取り出すことができる。

【００９１】回折光成分A_1と回折光成分A_2の合成ベクトルと偏光子の方位とを平行にした場合、偏光子を透過する光強度は$|T_1+T_2|^2$に比例する。$|T_1|=|T_2|$であれば、$\theta=45°$で２つの回折光成分の和がとれる。即ち、偏光子４９の透過軸を４５°にすれば、偏光子４９を透過する光強度は$|T_1+T_2|^2$に比例するようになり、２つの画像の加算出力が得られる。また、回折光成分A_1と回折光成分A_2の合成ベクトルと偏光子の方位とを直交にした場合、偏光子を透過する光強度は$|T_1-T_2|^2$に比例する。$|T_1|=|T_2|$であれば、$\theta=135°$で２つの回折光成分の差がとれる。即ち、偏光子４９の透過軸を１３５°にすれば、偏光子４９を透過する光強度は$|T_1-T_2|^2$に比例するようになり、２つの画像の減算出力が得られる。

【００９２】振幅T_1およびT_2で表される２つの画像が、それぞれ、図１４（Ａ）及び（Ｂ）に示すように、光の「明」（データ“１”）と「暗」（データ“０”）で表される２値画像である場合には、２つの画像の減算出力$|T_1-T_2|^2$も２値データとなり、図１４（Ｄ）に示したように２つの画像の排他的論理和（ＸＯＲ）と等価になる。一方、２つの画像の加算出力$|T_1+T_2|^2$は“１＋１”、“１”、“０”の３つの値（明るさ）を有するが、しきい値処理することによって、“１＋１”と“１”を「明」、“０”を「暗」とすれば、図１４（Ｃ）に示したように２つの画像の論理和（ＯＲ）が得られる。

【００９３】以上の通り、本発明の光記録媒体は、透明基板の一面側に光誘起複屈折性を示す光感応型の記録層を形成して構成されているが、再生時に読出光として照射するレーザ波長においては、透明基板の屈折率n_2は記録層１２の屈折率n_1よりも低いので、記録層がスラブ型光導波路となり、端面から入射された読出光が該記録層を導波することができる。

【００９４】また、本発明のホログラム記録再生方法及

びホログラム記録再生装置では、記録時には、光記録媒体の記録層に感度がある波長のレーザ光を、参照光として記録層に狭い角度で入射させて記録するので、導波損失が問題とならずホログラムを記録することができる。また、読み出し時には、光記録媒体の記録層が保持する屈折率または吸収率を変化ない波長のレーザ光を、読出光として記録層に導波させて回折光を得るので、記録されたホログラムを破壊すること無く再生することができる。

【００９５】また、本発明のホログラム記録再生方法を用いて、偏光感応型の光記録媒体に信号光の偏光を偏光ホログラムとして記録し、再生することができる。この偏光ホログラムは、その回折光として信号光の偏光方向が保存された光を発生させるので、信号光の偏光角を所定角度ずつ回転させることにより、偏光角の違いによる情報の記録及び読み出しが可能になる。

【００９６】更に、本発明のホログラム記録再生方法を用いて、信号光と参照光の偏光方向を互いに平行な方向と互いに直交する方向の２通りとすることにより、偏光感応型の光記録媒体の同一領域に、２つの信号光を２枚のホログラムとして多重に記録することができ、この光記録媒体の前記領域に、読出光を照射して、互いに直交する偏光方向を有する２つの回折光成分が合成された回折光を得、この回折光から任意の偏光成分を取り出すことによって、前記領域に２つの信号光として記録されている２つのデータ間の演算出力を得ることができる。即ち、光記録媒体に記録されている２つの画像などのデータ間で、和または差の演算や論理演算などの任意の演算を、簡便かつ高速に行うことができる。

【００９７】

【発明の効果】本発明の光記録媒体は、十分な回折効率が得られるホログラムを記録することができると共に、記録層がスラブ型光導波路となり、端面から入射された読出光が該記録層を導波することができる、という効果を奏する。

【００９８】本発明のホログラム記録再生方法及びホログラム記録再生装置は、十分な回折効率が得られるホログラムを記録することができると共に、記録層に端面から入射させた読出光を導波させて、記録されたホログラムを破壊することなく再生することができる、という効果を奏する。

【００９９】本発明の光記録装置は、十分な回折効率が得られるホログラムを記録することができる、という効果を奏する。また、本発明の光再生装置は、記録層に端面から入射させた読出光を導波させて、記録されたホログラムを破壊することなく読み出すことができる、という効果を奏する。

【図面の簡単な説明】

【図１】（Ａ）は、本発明の光記録媒体の構成を示す斜視図であり、（Ｂ）は、本発明の光記録媒体の他の構成

を示す斜視図である。

【図２】（Ａ）及び（Ｂ）は、光強度分布によるホログラムと偏光分布によるホログラムとを説明するための説明図である。

【図３】（Ａ）及び（Ｂ）は、本発明のホログラム記録再生装置の構成の一例を示す断面図である。

【図４】本発明のホログラム記録再生装置に用いられる空間変調器の構成を示す断面図である。

【図５】本発明のホログラム記録再生装置の構成の他の例を示す断面図である。

【図６】信号光の波数ベクトル、参照光の波数ベクトル、読出光の波数ベクトル、及び形成される格子ベクトルの関係を示す線図である。

【図７】参照光の入射角度が小さい場合の入射方法を示す断面図である。

【図８】本発明のホログラム記録再生方法により回折光の読み出しを行う様子を示す断面図である。

【図９】読出光を図８とは逆方向に導波させて回折光として位相共役光を得る様子を示す断面図である。

【図１０】本発明のホログラム記録再生方法を偏光ホログラム記録に適用した場合における、信号光の偏光分布を表す図である。

【図１１】（Ａ）は、図１０に示す信号光を記録した偏光ホログラムに基づいて得られた回折光の０°偏光成分の画像を表す図であり、（Ｂ）は９０°偏光成分の画像を表す図である。

【図１２】図１０に示す信号光を記録した偏光ホログラムに基づいて得られた再生像の偏光角を、信号光の偏光角に対してプロットした線図である。

【図１３】（Ａ）及び（Ｂ）は、本発明の光記録装置の他の構成例を示す断面図である。

【図１４】本発明のホログラム記録再生方法を偏光ホログラム多重記録に適用した場合における、（Ａ）及び（Ｂ）は入力画像であり、（Ｃ）及び（Ｄ）は（Ａ）及び（Ｂ）に示す入力画像を処理して得られる出力画像である。

【図１５】偏光ホログラム多重記録における、信号光の偏光方向、回折光の偏光方向、及び偏光子の方位の関係を示す線図である。

【符号の説明】

１　信号光
２　参照光
３　読出光
４　回折光
１０　光記録媒体
１１　透明基板
１２　記録層
１３　クラッド層
２０　１／２波長板
３０　空間光変調器

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２１　コンピュータ
４０　光源
４１　ビームスプリッタ
４３、４４、４５、４６　レンズ

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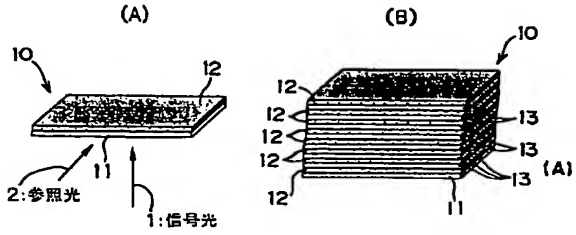
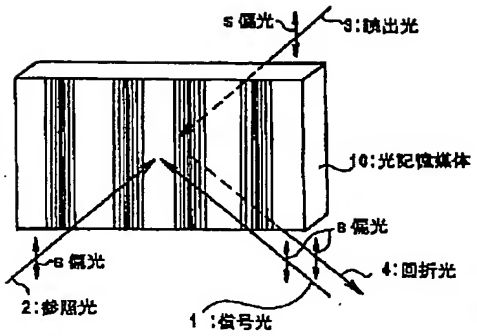
４７、４８　ミラー
４９　偏光子
５０　光検出器

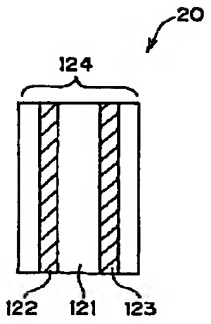
【図１】



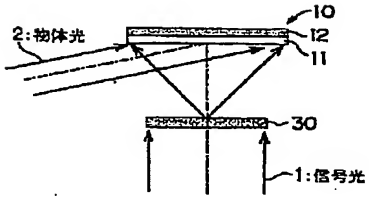
【図２】

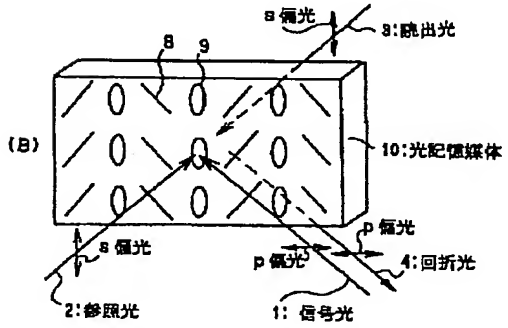


【図４】

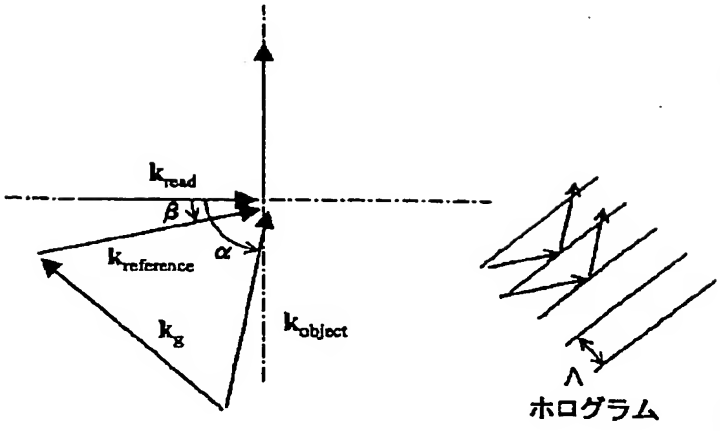


【図５】

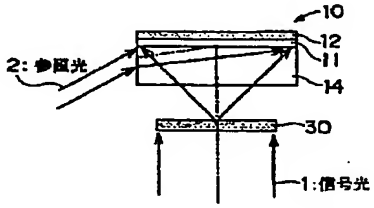




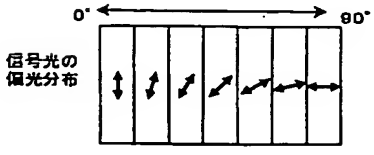
【図６】



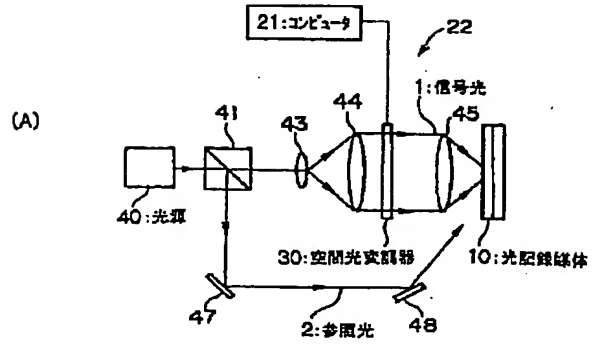
【図７】



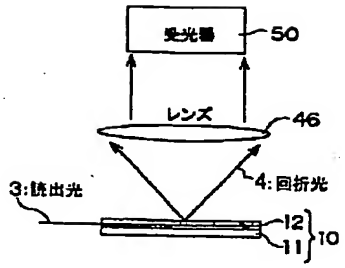
【図１０】



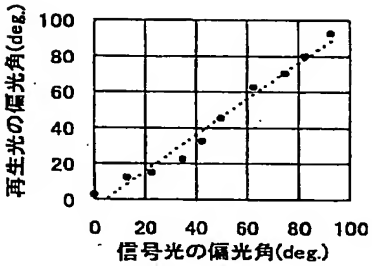
【図３】



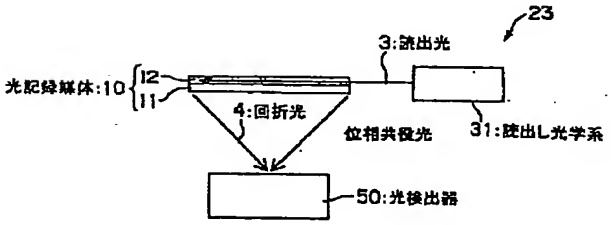
【図８】



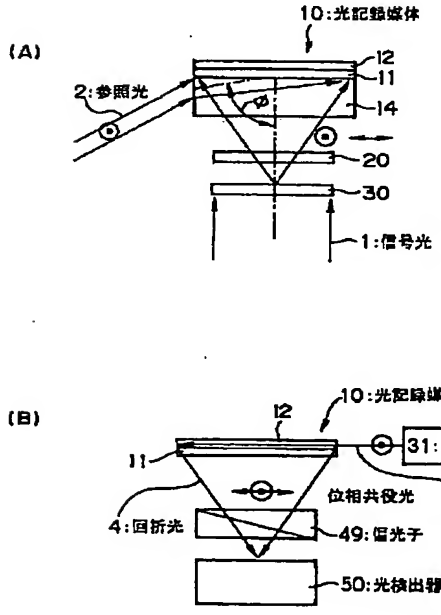
【図１２】



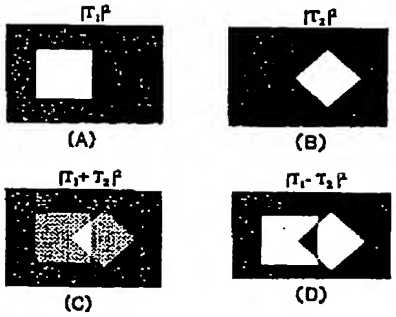
【図９】



【図１３】



【図１４】



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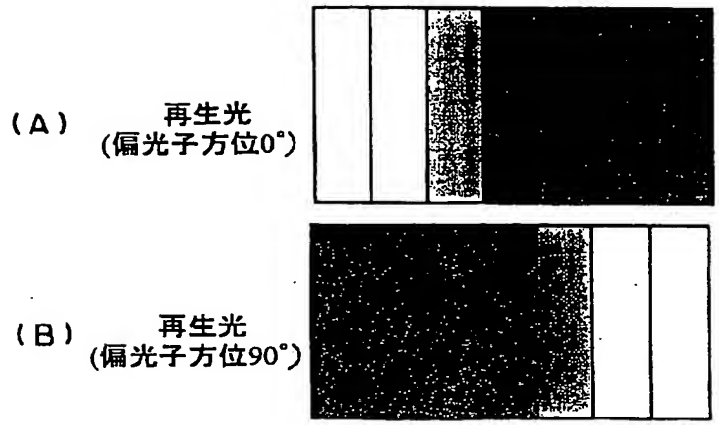

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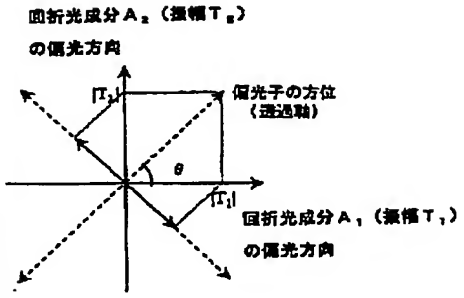

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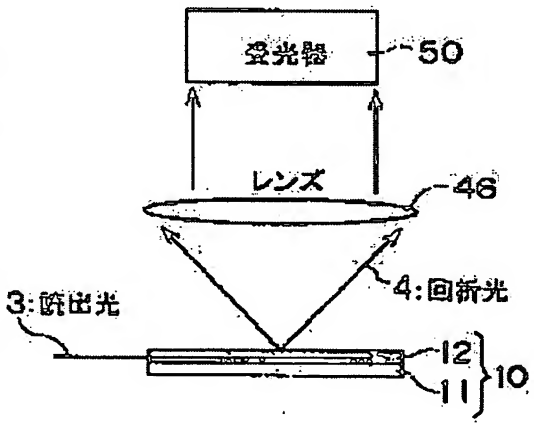
(54) OPTICAL RECORD MEDIUM, HOLOGRAM RECORD REPRODUCING METHOD, HOLOGRAM RECORD REPRODUCING DEVICE, OPTICAL RECORDER AND OPTICAL REPRODUCING DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a hologram record reproducing method or the like which makes it possible to record a hologram by which an ample diffraction efficiency is achieved and read out without breakage the hologram recorded through the guided wave of a readout beam which causes an incidence upon the recording layer from the end face.

SOLUTION: The light is subjected to the guided wave on the surface of a transparent substrate 11 at an incident angle greater than that of a determined value relative to this surface. A refractive index or an absorptive index is varied by the simultaneous irradiation of the signal beam and the reference beam each having a specified wavelength. The refractive index or the absorptive index varied is retained then an optical record medium 10 is used by which a recording layer 12 capable of recording the hologram is formed. When recorded, the hologram is recorded by simultaneously irradiating to the recording layer 12 the signal beam and the reference beam each having a prescribed wavelength. When reproduced, the recording layer 12 is subjected to the guided wave of a readout beam 3 of the wavelength which does not vary the refractive index or the absorptive index which is held by the recording layer 12. The hologram is reproduced by the diffracted light generated when the guided wave is forced to occur. This causes no problem with the guided wave loss upon being recorded. The recorded hologram can be reproduced without breakage upon being reproduced.



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* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] The optical recording medium with which it changes, and a refractive index or an absorption coefficient holds the refractive index or absorption coefficient which changed, and contains the recording layer which can record a hologram a substrate and by irradiating simultaneously the signal light and the reference beam of predetermined wavelength while it is formed on this substrate front face and whenever [over said front face / incident angle] guides the light beyond a predetermined value.
[Claim 2] An optical recording medium according to claim 1 with the refractive index of said recording layer higher than the refractive index of said substrate.
[Claim 3] The optical recording medium according to claim 1 or 2 which contains further the cladding layer which is formed on said recording layer and has a refractive index lower than this recording layer.
[Claim 4] An optical recording medium given in any 1 term of claims 1-3 which carried out two or more set laminating of said recording layer and said cladding layer.
[Claim 5] Said recording layer is an optical recording medium given in any 1 term of claims 1-4 which consisted of the macromolecules or polymer liquid crystals which have the radical photoisomerized to a side chain while having optical induced birefringence nature.
[Claim 6] The optical recording medium according to claim 5 with which said radical to photoisomerize contains the azobenzene frame.
[Claim 7] The optical recording medium according to claim 5 or 6 said whose macromolecules or polymer liquid crystals are at least one sort of monomer polymers chosen from the polyester group.
[Claim 8] While recording a hologram on an optical recording medium given in any 1 term of claims 1-7, it is the hologram record playback approach which reproduces the recorded hologram. At the time of record A hologram is recorded on said recording layer by irradiating simultaneously the signal light and the reference beam of predetermined wavelength. At the time of playback The hologram record playback approach which reproduces a hologram by the diffracted light at the time of making said recording layer guide waves and making the read-out light of wavelength to which the refractive index or absorption coefficient held at the recording layer is not changed guide.
[Claim 9] The hologram record playback approach according to claim 8 which reproduces a hologram by the diffracted light at the time of making said recording layer guide read-out light while irradiating the signal light which holds data information according to polarization distribution at an optical recording medium at a reference beam and coincidence and recording polarization distribution of this signal light as a hologram.
[Claim 10] The hologram record playback approach according to claim 9 which carries out polarization distribution by rotating the polarization angle of said signal light a predetermined include angle every according to said data information.
[Claim 11] The signal light which holds the 1st data information according to intensity distribution is irradiated to the predetermined field of an optical recording medium at a reference beam and coincidence. Record this signal luminous-intensity distribution as the 1st hologram, and the polarization condition of either said signal light and said reference beam is changed. While irradiating the signal light which holds the 2nd data information according to intensity distribution to the predetermined field of an optical recording medium at a reference beam and coincidence and carrying out multiplex record of this signal luminous-intensity distribution as the 2nd hologram The hologram record playback approach according to claim 8 which reproduces the 1st hologram and 2nd hologram by the diffracted light at the time of making said recording layer guide read-out light.
[Claim 12] While recording a hologram on an optical recording medium given in any 1 term of claims 1-7 The signal Mitsuteru gunner stage which is the hologram record regenerative apparatus which reproduces the recorded hologram, and irradiates the signal light of predetermined wavelength to the predetermined field of said recording layer from the waveguide direction of a recording layer, and the crossing direction, So that the refractive index or absorption coefficient of a recording layer may be changed by interferential action with said signal light The hologram record regenerative apparatus equipped with a read-out light incidence means to carry out incidence of the read-out light of wavelength to which a reference beam exposure means to irradiate the reference beam of said predetermined wavelength to said predetermined field, and the refractive index or absorption coefficient held at said recording layer is not changed to said recording layer so that this read-out light may guide said recording layer.
[Claim 13] It is an optical recording medium recordable on said recording layer about the hologram which can diffract the diffracted light when incidence of the read-out light which is an optical recording medium equipped with a recording layer, and guides the inside of said recording layer is carried out.
[Claim 14] The optical recording medium with which the hologram which can diffract the diffracted light when incidence of the read-out light which is an optical recording medium equipped with a recording layer, and guides the inside of said recording layer is carried out is recorded on said recording layer.
[Claim 15] The aforementioned read-out light is an optical recording medium according to claim 13 or 14 which is a light unrecordable on said recording layer.
[Claim 16] It is the optical recording medium according to claim 13 or 14 which is the light to which said hologram is recorded by change of the refractive index of said recording layer, or an absorption coefficient, and the aforementioned read-out light does not carry out induction of the change of said refractive index of said recording layer, or said absorption coefficient.
[Claim 17] The aforementioned read-out light is an optical recording medium according to claim 13 or 14 by which incidence is carried out from the end face of said sheet-like recording layer.
[Claim 18] Optical recording equipment equipped with a record means to record the hologram which can diffract the diffracted light when incidence of the read-out light which is optical recording equipment which records a hologram on the recording layer of an

optical recording medium, and guides the inside of said recording layer is carried out on said recording layer.
[Claim 19] Photo-regenerating equipment equipped with a read-out means to carry out incidence of the read-out light which is photo-regenerating equipment which makes the diffracted light diffract from the recording layer of the optical recording medium with which the hologram was recorded, and guides the inside of said recording layer, and to make said diffracted light diffract from said recording layer.

[Translation done.]

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DETAILED DESCRIPTION

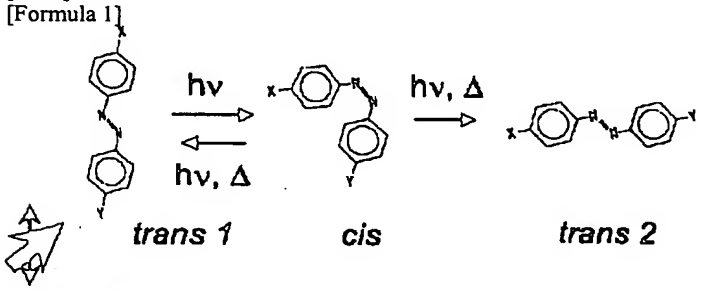
[Detailed Description of the Invention]
[0001]
[Field of the Invention] Especially this invention relates to a three-dimension image, a two-dimensional image or the optical recording medium that constitutes the holographic memory which can record a digital data page, the hologram record playback approach, a hologram record regenerative apparatus, optical recording equipment, and photo-regenerating equipment about an optical recording medium, the hologram record playback approach, a hologram record regenerative apparatus, optical recording equipment, and photo-regenerating equipment.
[0002]
[Description of the Prior Art] The 2-dimensional optical memory represented by the digital Vaasa tile disk (DVD) etc. is used as a record medium of large capacity and high density. Densification of these 2-dimensional optical memory has been realized by making small the laser spot used for record and playback of data short-wavelength-izing of record laser wavelength, and by enlarging the numerical aperture (NA;Numerical Aperture) of the objective lens used for pickup. And researches and developments of the 2-dimensional optical memory which made current and purple-blue color laser the light source are done briskly.
[0003] However, in the ultraviolet region, it is thought from the reason of a suitable optical material not existing but the suitable optical material used for an archive medium, a lens, etc. stopping existing etc. that it is difficult for short wavelength-ization of record laser wavelength to be a limitation and even for the activity of purple-blue color laser to short-wavelength-ize it more than this. Moreover, the approach of using numerical aperture high as twice [refractive-index] prism is proposed using the solid-state immersion lens (SIL:Solid Immersion Lens) which makes a condensing spot small as an approach of enlarging NA using circular prism with a high refractive index. By this approach, a minute condensing spot is formed using the EBANESSENTO light formed in a prism base. EBANESSENTO light is a non-spreading light which carries out localization near the prism base (outgoing radiation edge), since it exists only in the field below the wavelength of light from the outgoing radiation edge of SIL, must arrange a record medium near the pole at the base of prism, and must perform record and playback. For this reason, there are many technical problems which should be solved, such as establishment of the distance control of a record medium and prism and the portability of a record medium. Moreover, the refractive index of a prism ingredient is at most about two, and its recording density also improves only to about 4 times.
[0004] From the above reason, the improvement in recording density has reached the limitation in the present 2-dimensional optical memory. Therefore, in order to record 50GB or more of high density, it is necessary to record information by three dimensions including the depth direction of a record medium (volume record).
[0005] The holographic memory which records information in the form of a hologram is Motomitsu Mitsugi memory, and the record in large capacity is possible for it. Moreover, holographic memory is page mold memory and has the rapidity by package record and playback in the page unit of two-dimensional data. For this reason, holographic memory attracts attention as a next-generation record medium.
[0006] Holography is a technique recorded and reproduced through the amplitude (reinforcement) of a light wave, and the information on a phase. If incidence of the one more coherent light (reference beam) is simultaneously carried out to a record medium in case a coherent light is irradiated like a laser beam at a body and incidence of the reflected light (body light) from a body is carried out to a record medium, an interference fringe will be formed on a record medium. It is the hologram which recorded the optical intensity distribution by this interference into the medium as change of a refractive index or an absorption coefficient. If incidence only of the reference beam is carried out to the record medium with which the hologram was recorded, a hologram will work as a diffraction grating and body light will be reproduced.
[0007] Moreover, hologram record of digital data is also possible by changing digital data (binary data of 0 or 1) into ON/off-(**/dark) pattern using a space optical modulator, and carrying out incidence to a record medium as a body light in holographic memory. The original binary data are reproducible from the acquired electrical signal by irradiating a reference beam at a record medium, reproducing body light, and receiving and carrying out photo electric translation of the reproduced body light by the photodetector. Recently, the research from more nearly engineering viewpoints, such as S/N based on the concrete optical system and the volume multiplex recording method of this digital holographic memory, bit error rate assessment or a proposal of two-dimensional coding, and effect of the aberration of optical system, is progressing.
[0008] as a hologram record ingredient -- cheap -- the shape of a disk -- shaping -- the easy polymer ingredient attracts attention. For the media of a ROM mold, the so-called photopolymer is studied briskly, and the light-sensitive nature polymer containing a photoisomerization radical like azo is promising for rewritable media.
[0009] In order to realize large capacity-ization by holographic memory, while increasing the thickness of the recording layer which records a hologram, it is necessary to carry out multiplex record of two or more holograms into the same volume. For example, in order to accumulate 100GB or more of digital data in the disk of one sheet, the thickness of a recording layer is required 1mm or more. However, in the actual condition, it is dramatically difficult to thick-film-ize a recording layer, maintaining optical quality, and it requires cost.
[0010] There is invention indicated by JP,9-101735,A as an approach which realized large capacity-ization, avoiding this problem. The record / playback approach using the optical recording medium of the optical waveguide mold of a multilayer configuration is indicated by JP,9-101735,A. This optical recording medium carries out two or more laminatings of a lightguide and the recording layer through a cladding layer on a substrate, and the lightguide inserted into the adjoining cladding layer constitutes optical waveguide. Using this optical recording medium, to each optical waveguide, selectively, incidence of the reference beam is carried out, carry out incidence of the body light (signal light) from the interface of a lightguide, the EBANESSENTO light and body light

which oozed out to the recording layer are made to interfere, and a hologram is recorded from the end face of a lightguide. In this case, the thickness of the recording layer which takes a hologram to record one sheet may be as thin as several micrometers, and it is possible to produce a film, without spoiling optical quality by the spin coat or the cast method. Multiplex hologram record is attained by carrying out two or more laminatings of the recording layer of such a thin film.
[0011]
[Problem(s) to be Solved by the Invention] However, there is a trouble shown below in the record / playback approach using the optical recording medium of the optical waveguide mold of the multilayer configuration indicated by JP,9-101735,A mentioned above. although make a waveguide guide the reference beam used for record, the EBANESSENTO light and body light which oozed out to the recording layer are made to interfere and a hologram is recorded in this optical recording medium -- EBANESSENTO light -- at most -- since only wavelength order reaches a recording layer, a hologram is unrecordable in sufficient depth for the medium thickness direction, and since EBANESSENTO light is very feeble, sufficient exposure reinforcement is not obtained. Consequently, diffraction efficiency sufficient in the recorded hologram is not acquired. Moreover, it is difficult to irradiate the read-out light of reinforcement sufficient also at the time of playback.
[0012] In order to solve these problems, the reference beam and body light which a recording layer is made to guide a reference beam and read-out light, and guide not EBANESSENTO light but a recording layer are made to interfere, a hologram is recorded, and to reproduce a hologram by the read-out light which guides a recording layer is desired. However, the recording layer consists of ingredients which absorb a reference beam, in order to record a hologram. For this reason, in having carried out incidence of the reference beam to the recording layer from the end face, and having made waves guide, waveguide loss cannot record a hologram greatly. Moreover, although the light of the same wavelength as a reference beam is usually used for read-out light, the recorded hologram will be destroyed in having made read-out light guide at the time of playback.
[0013] This invention is made in view of the above-mentioned situation, and while the object of this invention can record the hologram from which sufficient diffraction efficiency is acquired, the read-out light by which incidence was carried out from the end face is to offer the optical recording medium which can guide a recording layer.
[0014] Other objects of this invention are to offer the hologram record playback approach and hologram record regenerative apparatus which can be read without destroying the hologram which the recording layer was made to guide the read-out light which carried out incidence, and was recorded on it from the end face while being able to record the hologram from which sufficient diffraction efficiency is acquired.
[0015] The object of further others of this invention is to offer the photo-regenerating equipment which can be read without destroying the optical recording equipment which can record the hologram from which sufficient diffraction efficiency is acquired, and the hologram which the recording layer was made to guide the read-out light which carried out incidence, and was recorded on it from the end face.
[0016]
[Means for Solving the Problem] In order to attain the above-mentioned object, the 1st optical recording medium of this invention While it is formed a substrate and on this substrate front face and whenever [over said front face / incident angle] guides the light beyond a predetermined value It is characterized by for the refractive index or the absorption coefficient having changed, having held the refractive index or absorption coefficient which changed, and constituting including the recording layer which can record a hologram by irradiating simultaneously the signal light and the reference beam of predetermined wavelength.
[0017] Although a refractive index or an absorption coefficient changes, holds the refractive index or absorption coefficient which changed and the recording layer which can record a hologram is formed by irradiating simultaneously the signal light and the reference beam of predetermined wavelength on the substrate front face, the 1st optical recording medium of this invention Since whenever [over a substrate front face / incident angle] guides the light beyond a predetermined value, this recording layer can reproduce a hologram by the diffracted light at the time of being able to make a recording layer guide read-out light at the time of playback, and making waves guide.
[0018] In the 1st above-mentioned optical recording medium, by making the refractive index of said recording layer higher than the refractive index of said substrate, a recording layer serves as slab mold optical waveguide, and the light by which incidence was carried out to the recording layer by whenever [beyond a predetermined value / incident angle] can be guided. Moreover, the cladding layer which has a refractive index lower than this recording layer can be further formed on said recording layer. Furthermore, two or more set laminating of said recording layer and said cladding layer can be carried out, and it can also consider as the optical recording medium of the multilayer configuration equipped with two or more recording layers.
[0019] The ingredient in which optical induced birefringence nature (called optical induction dichroism or an optical induction anisotropy) is shown can induce the polarization condition of the light which carries out incidence to this, and can record the polarization direction of incident light. The macromolecule or polymer liquid crystal which has also in this the radical photoisomerized to a side chain is excellent in the recording characteristic. Therefore, as an optical recording medium, while having optical induced birefringence nature, what prepared the recording layer which consists of the macromolecule or polymer liquid crystal which has the radical photoisomerized to a side chain is desirable. As a radical to photoisomerize, the thing containing an azobenzene frame is desirable and at least one sort of monomer polymers chosen from the polyester group are desirable as a macromolecule or a polymer liquid crystal.
[0020] The 2nd optical recording medium of this invention is equipped with the recording layer, and when incidence of the read-out light which guides the inside of this recording layer is carried out, it can record the hologram which can diffract the diffracted light on said recording layer. And by recording a hologram on this optical recording medium, when incidence of the read-out light which guides the inside of a recording layer is carried out, the hologram which can diffract the diffracted light can obtain the optical recording medium recorded on the recording layer.
[0021] In the 2nd optical recording medium of this invention, in order to obtain the diffracted light from the hologram recorded when incidence of the read-out light which guides the inside of a recording layer was carried out with sufficient diffraction efficiency, a read-out light unrecordable on a recording layer can be used. For example, when the hologram is recorded by change of the refractive index of a recording layer, or an absorption coefficient, the light which does not carry out induction of the change of the refractive index of a recording layer or an absorption coefficient can be used for read-out light.
[0022] Moreover, a recording layer can be made to guide read-out light by carrying out incidence of the read-out light from the end face of a sheet-like recording layer.
[0023] The hologram record playback approach of this invention is the hologram record playback approach which reproduces the recorded hologram while recording a hologram on the optical recording medium of this invention. At the time of record A hologram is recorded on said recording layer by irradiating simultaneously the signal light and the reference beam of predetermined wavelength. At the time of playback It is characterized by reproducing a hologram by the diffracted light at the time of making said recording layer

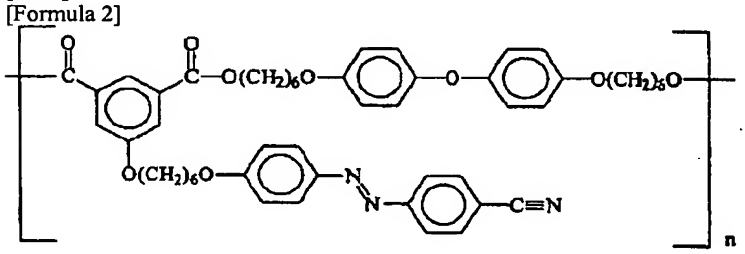
guide waves and making the read-out light of wavelength to which the refractive index or absorption coefficient held at the recording layer is not changed guide.
[0024] While the hologram record regenerative apparatus of this invention records a hologram on the optical recording medium of this invention The signal Mitsuteru gunner stage which is the hologram record regenerative apparatus which reproduces the recorded hologram, and irradiates the signal light of predetermined wavelength to the predetermined field of said recording layer from the waveguide direction of a recording layer, and the crossing direction, So that the refractive index or absorption coefficient of a recording layer may be changed by interferential action with said signal light It is characterized by having a read-out light incidence means to carry out incidence of the read-out light of wavelength to which a reference beam exposure means to irradiate the reference beam of said predetermined wavelength to said predetermined field, and the refractive index or absorption coefficient held at said recording layer is not changed to said recording layer so that this read-out light may guide said recording layer.
[0025] Although a hologram is recorded on a recording layer by irradiating simultaneously the signal light and the reference beam of predetermined wavelength at the time of record in the hologram record playback approach and hologram record regenerative apparatus of this invention Since a hologram is reproduced by the diffracted light at the time of making a recording layer guide waves and making the read-out light of wavelength to which the refractive index or absorption coefficient held at the recording layer is not changed at the time of playback guide At the time of record, waveguide loss does not pose a problem, but it can reproduce, without destroying the recorded hologram at the time of playback.
[0026] While applying the above-mentioned hologram record playback approach, irradiating the signal light which holds data information according to polarization distribution at an optical recording medium at a reference beam and coincidence and recording polarization distribution of this signal light as a hologram, a hologram is reproducible with the diffracted light at the time of making said recording layer guide read-out light. Since this polarization hologram generates the light where the polarization direction of signal light was saved as that diffracted light, read-out of the information by the difference in a deflection angle becomes possible by making it rotate a predetermined include angle every, and, for example, carrying out polarization distribution of the polarization angle of signal light according to data information.
[0027] Moreover, the signal light which applies the above-mentioned hologram record playback approach, and holds the 1st data information according to intensity distribution Irradiate a reference beam and coincidence to the predetermined field of an optical recording medium, and this signal luminous-intensity distribution is recorded as the 1st hologram. The signal light which changes the polarization condition of either said signal light and said reference beam, and holds the 2nd data information according to intensity distribution While irradiating a reference beam and coincidence to the predetermined field of an optical recording medium and carrying out multiplex record of this signal luminous-intensity distribution as the 2nd hologram, the 1st hologram and 2nd hologram are reproducible with the diffracted light at the time of making said recording layer guide read-out light.
[0028] Read-out light is irradiated to said field of the optical recording medium with which two signal light which has this different polarization direction is recorded on the same field by the same reference beam. The operation output between two data currently recorded on said field as two signal light can be obtained by obtaining the diffracted light by which two diffracted-light components which have the polarization direction which intersects perpendicularly mutually were compounded, and taking out the polarization component of arbitration from this diffracted light. That is, arbitration, such as an operation of the sum or a difference and logical operation, can be calculated at simple and a high speed among data, such as two images currently recorded on the optical recording medium.
[0029] in addition, the optical recording equipment with which a hologram record regenerative apparatus records a hologram on the recording layer of an optical recording medium and the photo-regenerating equipment which makes the diffracted light diffract from the recording layer of the optical recording medium with which the hologram was recorded -- since -- it can constitute. Optical recording equipment and photo-regenerating equipment may be constituted in one, and may be constituted independently respectively.

[0030] The optical recording equipment of this invention is optical recording equipment which records a hologram on the recording layer of an optical recording medium, and when incidence of the read-out light which guides the inside of said recording layer is carried out, it is characterized by having a record means to record the hologram which can diffract the diffracted light on said recording layer. Moreover, the photo-regenerating equipment of this invention is photo-regenerating equipment which makes the diffracted light diffract from the recording layer of the optical recording medium with which the hologram was recorded, carries out incidence of the read-out light which guides the inside of said recording layer, and is characterized by having a read-out means to make said diffracted light diffract from said recording layer. That is, the optical recording equipment of this invention can record the hologram from which sufficient diffraction efficiency is acquired, and the read-out light which carried out incidence to the recording layer from the end face is made to guide, and the photo-regenerating equipment of this invention can be read, without destroying the recorded hologram.
[0031]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to a drawing.
(Hologram optical recording medium) The optical recording medium of this invention is explained first.
[0032] As shown in drawing 1 (A), an optical recording medium 10 forms the recording layer 12 which can record a hologram on the whole surface side of the transparence substrates 11, such as a quartz substrate and a plastic plate, and is constituted. Here, in the laser wavelength which irradiates as a read-out light at the time of playback, the refractive index n1 of a recording layer 12 is higher than the refractive index n2 of the transparence substrate 11, and a recording layer 12 serves as slab mold optical waveguide. Moreover, the refractive index n1 of a recording layer 12 is higher than the refractive index of an air space. In addition, the signal light (body light) 1 and the reference beam 2 at the time of record are irradiated from the transparence substrate 11 side so that it may illustrate.
[0033] Moreover, as shown in drawing 1 (B), the laminating of two or more sets of recording layers 12 and the cladding layer 13 is carried out by turns, and two or more slab mold waveguides can be produced, and it can also consider as the optical recording medium of the optical waveguide mold of a multilayer configuration. The refractive index of a cladding layer 13 can be set to the n2 [same] as the refractive index of the transparence substrate 11.
[0034] In the case of which [of drawing 1 (A) and (B)], a recording layer 12 is formed so that it may have a sufficiently big flare compared with the shape of a sheet, i.e., thickness. Preferably, an optical recording medium 10 is formed in the shape of a sheet as a whole. Moreover, as for an optical recording medium 10, it is desirable to consider as the shape of a disk configuration or a card type.
[0035] A refractive index or an absorption coefficient changes and a recording layer 12 can record a hologram, and as long as the refractive index or absorption coefficient which changed is the ingredient held in ordinary temperature, it may consist of what kind of ingredients. As a suitable ingredient, the ingredient of light-sensitive nature in which optical induced birefringence nature is shown is mentioned. The ingredient in which optical induced birefringence nature is shown can induce the polarization condition of the light which carries out incidence, and can record the polarization direction of incident light. In addition, the optical recording medium

which can record the hologram by the optical induced birefringence corresponding to polarization distribution is called the optical recording medium of a polarization induction mold.
[0036] Especially the macromolecule that distributed the macromolecule which has the radical photoisomerized to a side chain as an ingredient in which optical induced birefringence nature is shown, the polymer liquid crystal, or the molecule to photoisomerize is suitable. Moreover, as the radical to photoisomerize or a molecule, what contains an azobenzene frame, for example is suitable.
[0037] Here, an azobenzene is explained to an example about the principle of optical induced birefringence. An azobenzene shows photoisomerization of transformer-SHISU by the exposure of light, as shown in the following chemical formula. Before carrying out an optical exposure at an optical recording layer, many azobenzenes of a transformer object exist in an optical recording layer. Orientation of these molecules is carried out at random, and they see on a macro and are isotropic. If the linearly polarized light is irradiated [which is shown in an optical recording layer by the arrow head] from predetermined, one transformer which has an absorption shaft in the same bearing as the polarization bearing will be selectively photoisomerized by the cis- object. The molecule eased to two transformers with the absorption shaft which intersected perpendicularly with polarization bearing does not absorb light any longer, but is fixed to the condition. As a result, it sees on a macro and induction of the birefringence is carried out to the anisotropy of an absorption coefficient and a refractive index, i.e., dichroism. Generally, these properties are called optical induced birefringence nature, optical induction dichroism, or an optical induction anisotropy. Moreover, the these-excited anisotropy is eliminable by irradiating the light which is not polarized [the circular polarization of light or].
[0038]
[Formula 1]



[0039] Own orientation of a macromolecule can also change with photoisomerization and the macromolecule containing such a photoisomerization radical can carry out induction of the big birefringence. Thus, the birefringence by which induction was carried out is stable at below the glass transition temperature of a macromolecule, and suitable for record of a hologram.
[0040] The polyester which has a cyano azobenzene can be mentioned to the side chain expressed with the following chemical formula as a suitable example of the ingredient which constitutes a recording layer 12. This polyester originates in the optical induction anisotropy by photoisomerization of the cyano azobenzene of a side chain. Signal luminous intensity and the polarization direction are made into a hologram. It is recordable (). ["Holographic recording] and retrieval of polarized light by use of polyester containing cyanoazobenzene units in the side chain", KKawano, T.Ishii, J.Minabe, T.Niitsu, Y.Nishikata and K.Baba, Opt.Lett.Vol.24 (1999) pp.1269-1271.
[0041]
[Formula 2]



[0042] The optical recording medium 10 equipped with the recording layer 12 which consists of the above-mentioned polyester ingredient is producible by carrying out the cast and making it dry on the glass substrate which washed the chloroform solution of polyester. When the absorption spectrum of the optical recording medium 10 with which the recording layer 12 of 20 micrometers of thickness was formed was measured, the spectrum which has a peak near 365nm equivalent to pi-pi * transition of an azobenzene was obtained.
[0043] In addition, the production approach of an optical recording medium is not restricted to this, may carry out the spin coat of the ingredient of a recording layer on a substrate, may produce an optical recording medium, pours in the ingredient of a recording layer to a parallel plate cel, and may produce an optical recording medium. Moreover, the ingredient of a recording layer may be pasted up on a film-like substrate with a hotpress, and an optical recording medium may be produced.
[0044] (Principle of polarization hologram record) When recording a hologram on the optical recording medium 10 equipped with the recording layer 12 which consists of a giant molecule which distributed the giant molecule or liquid crystal polymer which has this azobenzene in a side chain, or the azobenzene, the respectively coherent signal light 1 and a respectively coherent reference beam 2 are simultaneously irradiated to the same field of an optical recording medium 10.
[0045] In this case, when the polarization direction of the signal light 1 and a reference beam 2 is mutually parallel (for example, as shown in drawing 2 (A), when both the signal light 1 and the reference beam 2 are s-polarized light), optical intensity distribution are produced in an optical recording medium 10 by two interferences of light wave of the signal light 1 and a reference beam 2. And when [of optical reinforcement] strong, as mentioned above, induction of the optical anisotropy is carried out by the isomerization cycle of a transformer-cis--transformer. Therefore, the grid of the absorption coefficient corresponding to optical intensity distribution or a refractive index is recorded as a hologram.
[0046] On the other hand, when the polarization direction of the signal light 1 and a reference beam 2 is made to intersect perpendicularly mutually (for example, as shown in drawing 2 (B), when signal light 1 is made into p-polarized light and a reference

beam 2 is made into s-polarized light), optical intensity distribution [like] when the polarization direction of the signal light 1 and a reference beam 2 is mutually parallel are not produced. Instead, the polarization direction is modulated spatially and periodically and the linearly polarized light part 8 and the elliptically-polarized-light part 9 appear periodically by turns.
[0047] In this case, although it becomes uniform [optical intensity distribution], as the azobenzene which turns to the same direction as the modulated polarization direction mentioned above, induction of the optical anisotropy is carried out by the isomerization cycle of a transformer-cis--transformer, and it is recorded as a hologram.
[0048] Henceforth, the hologram by optical intensity distribution when the polarization direction of the signal light 1 and a reference beam 2 is parallel is called a hologram on the strength [optical] like drawing 2 (A), and the hologram by polarization distribution in case the polarization direction of the signal light 1 and a reference beam 2 intersects perpendicularly like drawing 2 (B) is called a polarization hologram.
[0049] Thus, a hologram is recordable as a result of carrying out induction of the anisotropy of an azobenzene according to the optical recording medium 10 equipped with the recording layer 12 which consists of a giant molecule which distributed the giant molecule or liquid crystal polymer which has an azobenzene in a side chain, or the azobenzene, even if the polarization direction of the signal light 1 and a reference beam 2 is parallel and it lies at right angles.
[0050] The diffracted light 4 which has the same direction as the polarization direction of a reference beam 2, then the same polarization condition as the signal light 1 for the polarization direction of the hologram read-out light 3 in each above-mentioned case can be obtained. Moreover, the recorded hologram will be held without relaxation under the room temperature natural light for several years or more.
[0051] (Hologram record regenerative apparatus) An example of the hologram record regenerative apparatus of this invention is shown in drawing 3 . This hologram record regenerative apparatus consists of a recording device shown in drawing 3 (A), and a regenerative apparatus shown in drawing 3 R> 3 (B). A recording device and a regenerative apparatus may be constituted in one, and may be constituted independently respectively.
[0052] The recording device is equipped with the recording head 22 which irradiates simultaneously the signal light 1 and a reference beam 2, and records a hologram on the predetermined field of an optical recording medium 10 as shown in drawing 3 (A). A recording head 22 A coherent light The light from the light source 40 and the light source 40 to emit For signal light And the lenses 43 and 44 which carry out parallel Guanghua of the light wave which penetrated the beam splitter 41 divided into two light waves for reference beams, and the beam splitter 41, the space optical modulator 30 which modulates the light wave by which parallel Guanghua was carried out, the condenser lens 45 which condenses the modulated signal light 1 to the predetermined field of an optical recording medium 10, And it has the mirrors 47 and 48 led to the predetermined field of an optical recording medium 10 by making into a reference beam 2 the light wave reflected by the beam splitter 41. In addition, it connects with a computer 21 and the space optical modulator 30 is controlled by the computer 21.
[0053] What sensibility is in the ingredient of the recording layer 12 of an optical recording medium 10, and emits a coherent light as the light source 40 of a recording head 22 can be used. When using for a recording layer 12 the polyester which has a cyano azobenzene in a side chain, it is desirable to use an Ar ion laser with an oscillation wavelength [corresponding to the skirt of the absorption peak of an optical recording medium 10] of 515nm for the light source.
[0054] As a space optical modulator 30, the space optical modulator of the transparency mold in which the transparent electrode was formed to both sides of electro-optics conversion ingredients, such as liquid crystal, can be used. The liquid crystal panel for projectors can be mentioned as this type of a space optical modulator.
[0055] However, in order to make polarization modulation possible, to use the liquid crystal panel for the above-mentioned projectors, it is necessary to remove the polarizing plate arranged at least at the output side. For example, the space optical modulator 30 can be constituted as a liquid crystal cell 124 of the transparency mold in which electrodes 122 and 123 were formed to both sides of the liquid crystal 121 which is one of the electro-optics converter material, as shown in drawing 4 . In the space optical modulator which performs this polarization modulation, the polarization of light which carries out incidence to each pixel is modulated by forming two or more pixels two-dimensional, operating each pixel as 1/2 wavelength plate, and giving as existence of electrical-potential-difference impression of the information on the bit corresponding to each pixel in two-dimensional data.
[0056] The regenerative apparatus is equipped with the read-out optical system 31 for carrying out incidence of the coherent light from the end face of an optical recording medium 10, and the read station 23 which reads the diffracted light 4 by the recorded hologram as shown in drawing 3 (B). The read station 23 has the photodetectors 50, such as CCD which detects the lens 46 which carries out parallel Guanghua of the diffracted light 4, and the diffracted light by which incidence is carried out.
[0057] the read-out optical system 31 can be constituted including the light source which the refractive index or absorption coefficient which the hologram recorded on the recording layer 12 of an optical recording medium 10 holds is not changed, without destroying the recorded hologram namely,, and emits a coherent light. Although it is desirable to use He Ne laser with an oscillation wavelength of 633nm no sensibility is [wavelength] in the recording layer 12 of an optical recording medium 10 (there is no absorption) as the light source when using for a recording layer 12 the polyester which has a cyano azobenzene in a side chain, the other laser diode may be used.
[0058] (The hologram record playback approach) Next, the hologram record playback approach of this invention is explained.
[0059] First, the coherent light outputted from the light source 40 of a recording head 22 in the recording apparatus shown in drawing 3 (A) at the time of record is divided into the object for signal light, and two light waves for reference beams by the beam splitter 41. Let the light wave which penetrated the beam splitter 41 be a big parallel light of a light diameter with lenses 43 and 44. Then, the light wave by which parallel Guanghua was carried out is modulated by the space optical modulator 30, and the signal light 1 is generated.
[0060] the modulated signal light 1 -- a lens 45 -- a cutback -- or the Fourier transform is carried out and the predetermined field of an optical recording medium 10 irradiates. On the other hand, it is reflected by mirrors 47 and 48, and the reference beam 2 reflected by the beam splitter 41 is led to the predetermined field of an optical recording medium 10, and incidence is carried out to an optical recording medium 10 so that the signal light 1 may be intersected in an optical recording medium. Thus, hologram record is performed by irradiating the signal light 1 and a reference beam 2 simultaneously to the same field.
[0061] As the signal light 1 and a reference beam 2, the laser beam of the wavelength which has sensibility in the ingredient of the recording layer 12 of an optical recording medium 10 is used as mentioned above. Moreover, it can ask for whenever [incident angle / of the signal light 1 and a reference beam 2] as follows.
[0062] As shown in drawing 6 , when the wave number vector of the signal light 1 at the time of record and a reference beam 2 is set to kobject and kreference, respectively and the wave number vector of the read-out light 3 is set to kread, the include angles of kobject and kreference are alpha and beta, respectively on the basis of the direction of a vector of the read-out light 3, and the crossed axes angle of two light waves is alpha-beta. The grid vector formed of kobject and kreference is given by kg= kobject-kreference, and the

lattice spacing lambda of the recorded hologram is given by the following formula 1.
[0063]
[Equation 1]

$$\Lambda = \frac{\lambda}{2\sin\left(\frac{\alpha-\beta}{2}\right)}$$

式1

[0064] Here, the case where set to lambda wavelength of the signal light used for record and a reference beam, and the read-out light (wave number vector kread) of wavelength lambda' carries out incidence at an include angle 0 to a substrate side is considered. At this time, it is (alpha+beta)/2, and whenever [to a grid / incident angle] obtains the strong diffracted light, when fulfilling the phase matching conditions of the following type 2.
[0065]
[Equation 2]

$$\sin\left(\frac{\alpha+\beta}{2}\right) = m\frac{\lambda'}{2\Lambda} \qquad (m=1,2,3,\cdots)$$

式2

[0066] Since formulas 2 are conditions from which the reflected light from each class by the multiple echo becomes equiphase, the relation of a formula 3 is drawn by a formula 1 and the formula 2.
[0067]
[Equation 3]

$$m\frac{\lambda'}{\lambda} = \frac{\sin\left(\frac{\alpha+\beta}{2}\right)}{\sin\left(\frac{\alpha-\beta}{2}\right)}$$

式3

[0068] When it was alpha and beta which fill a formula 3 and read-out light guides waveguide, the phase matching conditions of a hologram can be fulfilled and the diffracted light can be obtained. The conditions in which the diffracted light carries out outgoing radiation vertically to waveguide are whenever [to a grid / incident angle], / (alpha+beta) case of 2= 45 degrees. If this condition is substituted for a formula 3, alpha and beta which were respectively expressed with the formula 4 and the formula 5 will be called for. That is, beta is [whenever / incident angle / of signal light / alpha /, and, whenever / incident angle / of a reference beam] computable according to the value, if wavelength lambda[of the wavelength lambda of signal light and a reference beam and read-out light] ' is decided.
[0069]
[Equation 4]

$$\beta = 45 - \sin^{-1}\left(\frac{\sqrt{2}}{2m}\frac{\lambda}{\lambda'}\right)$$

式4

$$\alpha = 45 + \sin^{-1}\left(\frac{\sqrt{2}}{2m}\frac{\lambda}{\lambda'}\right)$$

式5

[0070] For example, as lambda= 515nm, lambda'=633nm, and m= 1, if it asks for alpha and beta, it is [whenever / incident angle / of signal light / whenever / alpha= 80 degree and incident angle / of a reference beam] computable with beta= 10 degrees.
[0071] Next, incidence of the coherent light outputted from the read-out optical system 31 in the regenerative apparatus shown in drawing 3 (B) at the time of read-out is carried out from the end face of the recording layer 12 of an optical recording medium 10 as a read-out light 3. As shown in drawing 8 , the read-out light 3 by which incidence was carried out guides a recording layer 12, and the diffracted light is diffracted from a recording layer 12. The diffracted light wave (diffracted light 4) carries out image formation of this to a photodetector 50 with a lens 46.
[0072] The laser beam of wavelength to which the refractive index or absorption coefficient which the hologram recorded on the recording layer 12 of an optical recording medium 10 holds as a read-out light 3 is not changed, for example, the laser beam of the wavelength which does not have sensibility in the ingredient of the recording layer 12 of an optical recording medium 10, is used as mentioned above. Thus, by using the laser beam of wavelength to which the refractive index or absorption coefficient which the hologram recorded on the recording layer 12 of an optical recording medium 10 at the time of playback holds is not changed as a read-out light 3, a recording layer 12 is made to guide the read-out light 3, and it can reproduce, without destroying the recorded hologram.
[0073] Moreover, since the read-out light 3 guides a recording layer 12, the hologram recorded along with the waveguide of the read-out light 3 can be read at once.
[0074] In addition, as shown in drawing 5 , when incidence of the signal light 1 modulated with the space modulator 30 is carried out to an optical recording medium 10, without minding a lens and hologram record is performed, as shown in drawing 9 R> 9, a recording layer 12 can be made to be able to guide the read-out light 3 from the direction of incidence of the reference beam 2 used for record, and the direction of reverse, and a hologram can also be read. In this case, since the wavelength of a reference beam 2 differs from the wavelength of the read-out light 3, although a scale factor and an optical path change, they can reproduce the phase

conjugation light of the signal light 1 as the diffracted light 4. Phase conjugation light is equipped with the same wave front as signal light, and reverses the optical path in which signal light carried out incidence. Therefore, image formation can be carried out to a photodetector 50, without using special image formation optical system. In this case, incidence of the read-out light 3 will be carried out from the end face of an optical recording medium 10, and the diffracted light 4 will be taken out from the incidence side of the signal light 1.

[0075] Moreover, what is necessary is to contact the glass substrate 14 of a refractive index thick [as the transparence substrate 11 / same] to the transparence substrate 11 side of an optical recording medium 10, and just to carry out incidence of the reference beam 2 from the side face of this glass substrate 14, as shown in drawing 7 in order to carry out incidence of the reference beam 2 to the optical recording layer 12 at the narrow include angle of 10 degrees. The reference beam 2 by which incidence was carried out from the side face of a glass substrate 14 is refracted by the interface of air and a glass substrate 14, and carries out incidence to the optical recording layer 12 at an include angle narrower than whenever [to a glass substrate 14 / incident angle]. Moreover, the transparence substrate 11 may be made sufficiently thick and incidence of the reference beam 2 may be carried out from the side face of the transparence substrate 11.

[0076] (Polarization hologram record) The example which performs polarization hologram record using the above-mentioned hologram record playback approach is explained. The hologram record regenerative apparatus shown in drawing 3 (A) and (B) performed record and playback using the optical recording medium of the polarization induction mold equipped with the recording layer which becomes the above mentioned side chain from the polyester which has a cyano azobenzene.

[0077] The crossed axes angle phi of signal light and a reference beam was made into 70 degrees at the light source 40 for record using the Ar ion laser with an oscillation wavelength of 515nm which has sensibility at the polyester which is the ingredient of a recording layer. Signal light with the polarization distribution shown in drawing 10 was generated using the space optical modulator 30 of a polarization modulation mold. Bearing of the linearly polarized light is changing for every pixel, and polarization bearing expresses data information with this signal light. Here, if bearing of N-ary is recorded, log2N bit data can be stored for every pixel.

[0078] Moreover, He Ne laser with an oscillation wavelength of 633nm which does not have sensibility in the polyester which is the ingredient of a recording layer was used for the light source of the read-out optical system 30. However, the recording layer was made to guide read-out light from the direction of incidence of the reference beam used for record, and the direction which counters, and the phase conjugation light of signal light was made to diffract. It separated into the polarization component (0-degree polarization component and 90-degree polarization component) which arranges an analyzer to the optical path of the diffracted light, and intersects perpendicularly with it. Consequently, two images of 0-degree polarization component and 90-degree polarization component as shown in drawing 1111 (A) and (B) were obtained. From the optical intensity-distribution ratio between these 2 images, the polarization angle rho of playback light was computed using the following type 6.

[0079]

[Equation 5]

$$\rho = \tan^{-1}\left(\sqrt{\frac{I_{90}}{I_0}}\right)$$

式 6

[0080] Here, I0 and I90 are the reinforcement of 0-degree polarization component of each pixel, and 90-degree polarization component, respectively. The result of having plotted the polarization angle of the acquired reconstruction image to the polarization angle of signal light is shown in drawing 12 . From drawing 12 , the polarization angle of a reconstruction image is changing to the abbreviation straight-line target to the polarization angle of signal light, and is understood that polarization bearing of signal light and polarization bearing of playback light are the same. Therefore, according to the hologram record playback approach of this invention, while polarization distribution of signal light is recordable, the recorded polarization distribution is faithfully reproducible.

[0081] In addition, although the example which performs record and playback of a hologram was explained using the signal light which holds data information according to polarization distribution above, record and playback of a hologram can be similarly performed about the signal light which holds data information according to amplitude (reinforcement) distribution or phase distribution. For example, playback of a stereoscopic model is also possible by recording the reflected light from a three-dimension body as a signal light.

[0082] Next, the above-mentioned hologram record playback approach is used. (Polarization hologram multiplex record) The example which performs hologram record to a duplex on two conditions in the case of intersecting perpendicularly with the case where the polarization direction of signal light and a reference beam is mutually parallel, Namely, make parallel the polarization direction of signal light and a reference beam in the 1st step, and hologram record is performed. The 90 degrees of the polarization directions of signal light (or reference beam) are rotated with 1/2 wavelength plate in the 2nd step, and the conditions which made the polarization direction of signal light and a reference beam intersect perpendicularly mutually explain the example which carries out multiplex record of the hologram of the 2nd sheet to the same field. However, even if it uses the circular polarization of light which intersects perpendicularly mutually, same polarization multiplex record and playback are possible.

[0083] Using the optical recording medium 10 of the polarization induction mold equipped with the recording layer 12 which becomes the above mentioned side chain from the polyester which has a cyano azobenzene, as shown in drawing 13 (A) Except having arranged 1/2 wavelength plate 20 between the space modulator 30 and an optical recording medium 10 As it considers as the same configuration as the recording device shown in drawing 7 and is shown in drawing 13 (B), between an optical recording medium 10 and a photodetector 50 Except having arranged the polarizers 49, such as a polarization beam splitter which separates the predetermined polarization component contained in the diffracted light 4, record and playback of a hologram were performed as the same configuration as the regenerative apparatus shown in drawing 9 .

[0084] An image is displayed on the space optical modulator 30 by computer which is not illustrated so that it may mention later, as shown in drawing 13 (A), as a light which passed the space optical modulator 30, the signal light which has the information on the image displayed on the space optical modulator 30 is obtained, 1/2 wavelength plate 20 is passed for this signal light, and it changes into the signal light 1 which has the predetermined polarization direction. The optical recording medium 10 which mentioned above the signal light 1 which passed this 1/2 wavelength plate 20 is irradiated. Simultaneously, a reference beam 2 is irradiated to the field to which the signal light 1 of an optical recording medium 10 is irradiated. The signal light 1 and a reference beam 2 interfere in an optical recording medium 10, and a hologram is recorded into an optical recording medium 10 by this.

[0085] In this case, in the 1st step, a binary image on the strength as shown in drawing 14 (A) is displayed on the space optical modulator 30 as an image of the 1st sheet. The hologram of the 1st sheet is recorded into an optical recording medium 10 that the polarization direction of the signal light 1 which passed this for 1/2 wavelength plate 20 is vertical to space (this is made into 0

degree), and by adjusting so that it may become, and irradiating the signal light 1 and a reference beam 2 simultaneously at an optical recording medium 10.
[0086] Next, in the 2nd step, a binary image on the strength as shown in drawing 14 (B) is displayed on the space optical modulator 30 as an image of the 2nd sheet. By adjusting 1/2 wavelength plate 20 so that the polarization direction of the signal light 1 which passed this may become in parallel with space (this is made into 90 degrees), and irradiating the signal light 1 and a reference beam 2 simultaneously at an optical recording medium 10 The hologram of the 2nd sheet is recorded on the field to which the hologram of the 1st sheet in an optical recording medium 10 was recorded. However, it is the polarization direction of a reference beam 2 at the hologram's record [of the 1st sheet], and hologram's record time of the 2nd sheet, and it is made the same.
[0087] At the time of read-out, as shown in drawing 13 (B), incidence of the coherent light outputted from the read-out optical system 31 is carried out from the end face of the recording layer 12 of an optical recording medium 10 as a read-out light 3. The read-out light 3 by which incidence was carried out guides a recording layer 12, and the secondary diffracted light is diffracted from a recording layer 12.
[0088] Image formation of the diffracted light 4 is carried out on the photodetectors 50, such as CCD, and the data image of the signal light 1 is read. That is, the reconstruction image from the hologram of two sheets recorded in the 1st step and the 2nd step can be acquired. However, as for each of the diffracted light from the hologram of two sheets, the polarization direction lies at right angles mutually. In this case, a polarizer 49 can be arranged between an optical recording medium 10 and a photodetector 50, and two diffraction figures can be separated and read by computer which is not illustrated by adjusting the transparency shaft of this polarizer 49 in the direction of arbitration. For example, the operation output of the arbitration between the image of the image of the 1st sheet, the image of the 2nd sheet, or the 1st sheet and the image of the 2nd sheet can be read as follows.
[0089] As shown in drawing 15 , when reading only the image of the 1st sheet, the transparency shaft of a polarizer 49 is made into 0 degree, and when reading only the image of the 2nd sheet, the transparency shaft of a polarizer 49 is made into 90 degrees. If the amplitude of the diffracted-light component A2 from the hologram of the 2nd sheet recorded in T1 and the 2nd step in the amplitude of the diffracted-light component A1 from the hologram of the 1st sheet recorded in the 1st step is set to T2 When the optical reinforcement which penetrates a polarizer 49 when the transparency shaft of a polarizer 49 is made into 0 degree is proportional to |T1|2 and the transparency shaft of a polarizer 49 is made into 90 degrees, the optical reinforcement which penetrates a polarizer 49 is proportional to |T2|2.
[0090] However, this is the case where polarization of the signal light 1 is faithfully reproduced to the diffracted light 4. Actually, the polarization direction of the diffracted light 4 may shift it of the signal light 1, and a little with optical system or the polarization property of an optical recording medium 10. However, even in such a case, since the polarization direction of two images by which multiplex record is carried out is maintained at the relation which intersected perpendicularly mutually, by adjusting the transparency shaft of a polarizer 49 suitably, without producing a cross talk, it can dissociate and it can take out two images.
[0091] When the synthetic vector of the diffracted-light component A1 and the diffracted-light component A2 and bearing of a polarizer are made parallel, the optical reinforcement which penetrates a polarizer is proportional to |T1+T2|2. | If it is T1|=|T2|, the sum of two diffracted-light components can be taken at theta= 45 degrees. That is, if the transparency shaft of a polarizer 49 is made into 45 degrees, the optical reinforcement which penetrates a polarizer 49 will come to be proportional to |T1+T2|2, and the addition output of two images will be obtained. Moreover, when the synthetic vector of the diffracted-light component A1 and the diffracted-light component A2 and bearing of a polarizer are made cross at right angles, the optical reinforcement which penetrates a polarizer is proportional to |T1-T2|2. | If it is T1|=|T2|, the difference of two diffracted-light components can be taken at theta= 135 degrees. That is, if the transparency shaft of a polarizer 49 is made into 135 degrees, the optical reinforcement which penetrates a polarizer 49 will come to be proportional to |T1-T2|2, and the subtraction output of two images will be obtained.
[0092] As shown in drawing 14 (A) and (B), two images expressed with amplitude T1 and T2, respectively In being the binary image expressed with "**" (data "1") and "dark" (data "0") of light, subtraction output |T1-T2|2 of two images become binary data, and as shown in drawing 14 (D), it becomes the exclusive OR (XOR) and equivalence of two images. On the other hand, although addition output |T1+T2|2 of two images have three values (brightness), "1+1", "1", and "0" By carrying out threshold processing, in "0", as "1+1" and "1" were shown in "**" and it was shown in "dark", then drawing 14 R> 4 (C), the OR (OR) of two images is acquired.
[0093] In the laser wavelength which irradiates as a read-out light at the time of playback, although the optical recording medium of this invention forms in the whole surface side of a transparence substrate the recording layer of the light-sensitive mold in which optical induced birefringence nature is shown as above and it is constituted, since the refractive index n2 of a transparence substrate is lower than the refractive index n1 of a recording layer 12, a recording layer serves as slab mold optical waveguide, and the read-out light by which incidence was carried out from the end face can guide this recording layer.
[0094] Moreover, in the hologram record playback approach and hologram record regenerative apparatus of this invention, at the time of record, since the recording layer of an optical recording medium is made to carry out incidence of the laser beam of wavelength with sensibility to a recording layer at a narrow include angle and it is recorded on it as a reference beam, waveguide loss does not pose a problem but can record a hologram. Moreover, since a recording layer is made to guide the laser beam of the wavelength which is not changeful as a read-out light for the refractive index or absorption coefficient which the recording layer of an optical recording medium holds and the diffracted light is obtained at the time of read-out, it can reproduce, without destroying the recorded hologram.
[0095] Moreover, using the hologram record playback approach of this invention, polarization of signal light can be recorded on the optical recording medium of a polarization induction mold as a polarization hologram, and it can reproduce. Since this polarization hologram generates the light where the polarization direction of signal light was saved as that diffracted light, the record and read-out of information by the difference in a polarization angle become possible by rotating the polarization angle of signal light a predetermined include angle every.
[0096] Furthermore, by making the polarization direction of signal light and a reference beam into two kinds, an parallel direction and the direction which intersects perpendicularly mutually, mutually using the hologram record playback approach of this invention To the same field of the optical recording medium of a polarization induction mold, can record two signal light on multiplex as a hologram of two sheets, and read-out light is irradiated at said field of this optical recording medium. The operation output between two data currently recorded on said field as two signal light can be obtained by obtaining the diffracted light by which two diffracted-light components which have the polarization direction which intersects perpendicularly mutually were compounded, and taking out the polarization component of arbitration from this diffracted light. That is, arbitration, such as an operation of the sum or a difference and logical operation, can be calculated at simple and a high speed among data, such as two images currently recorded on the optical recording medium.
[0097]
[Effect of the Invention] A recording layer serves as slab mold optical waveguide, and the optical recording medium of this invention does so the effectiveness that the read-out light by which incidence was carried out from the end face can guide this recording layer

while being able to record the hologram from which sufficient diffraction efficiency is acquired.
[0098] The hologram record playback approach and hologram record regenerative apparatus of this invention do so the effectiveness that the read-out light which carried out incidence to the recording layer from the end face is made to guide, and it can reproduce, without destroying the recorded hologram while being able to record the hologram from which sufficient diffraction efficiency is acquired.
[0099] The optical recording equipment of this invention does so the effectiveness that the hologram from which sufficient diffraction efficiency is acquired is recordable. Moreover, the photo-regenerating equipment of this invention does so the effectiveness that the read-out light which carried out incidence to the recording layer from the end face is made to guide, and it can read, without destroying the recorded hologram.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] (A) is the perspective view showing the configuration of the optical recording medium of this invention, and (B) is the perspective view showing other configurations of the optical recording medium of this invention.
[Drawing 2] (A) And (B) is an explanatory view for explaining the hologram by optical intensity distribution, and the hologram by polarization distribution.
[Drawing 3] (A) And (B) is the sectional view showing an example of the configuration of the hologram record regenerative apparatus of this invention.
[Drawing 4] It is the sectional view showing the configuration of the space modulator used for the hologram record regenerative apparatus of this invention.
[Drawing 5] It is the sectional view showing other examples of the configuration of the hologram record regenerative apparatus of this invention.
[Drawing 6] It is the diagram showing the relation of the wave number vector of signal light, the wave number vector of a reference beam, the wave number vector of read-out light, and the grid vector formed.
[Drawing 7] It is the sectional view showing the incidence approach when whenever [incident angle / of a reference beam] is small.
[Drawing 8] It is the sectional view showing signs that the diffracted light is read by the hologram record playback approach of this invention.
[Drawing 9] It is the sectional view showing signs that drawing 8 makes hard flow guide read-out light, and phase conjugation light is obtained as the diffracted light.
[Drawing 10] It is drawing showing polarization distribution of the signal light at the time of applying the hologram record playback approach of this invention to polarization hologram record.
[Drawing 11] (A) is drawing showing the image of 0-degree polarization component of the diffracted light obtained based on the polarization hologram which recorded the signal light shown in drawing 10 , and (B) is drawing showing the image of 90-degree polarization component.
[Drawing 12] It is the diagram which plotted the polarization angle of the reconstruction image acquired based on the polarization hologram which recorded the signal light shown in drawing 10 to the polarization angle of signal light.
[Drawing 13] (A) And (B) is the sectional view showing other examples of a configuration of the optical recording equipment of this invention.
[Drawing 14] (A) at the time of applying the hologram record playback approach of this invention to polarization hologram multiplex record and (B) are input images, and (C) and (D) are output images which process the input image shown in (A) and (B), and are obtained.
[Drawing 15] It is the diagram in polarization hologram multiplex record showing the relation of the polarization direction of signal light, the polarization direction of the diffracted light, and bearing of a polarizer.
[Description of Notations]
1 Signal Light
2 Reference Beam
3 Read-out Light
4 Diffracted Light
10 Optical Recording Medium
11 Transparence Substrate
12 Recording Layer
13 Cladding Layer
20 1/2 Wavelength Plate
30 Space Optical Modulator
21 Computer
40 Light Source
41 Beam Splitter
43, 44, 45, 46 Lens
47 48 Mirror
49 Polarizer
50 Photodetector

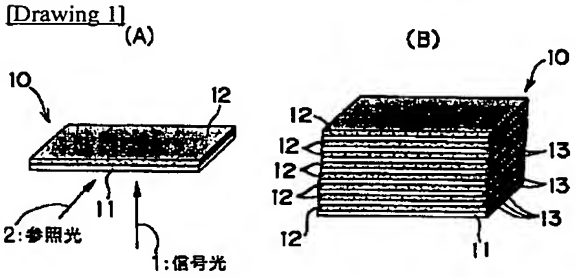
[Translation done.]

* NOTICES *

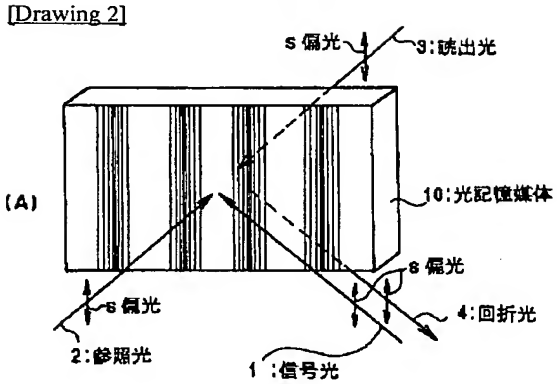
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

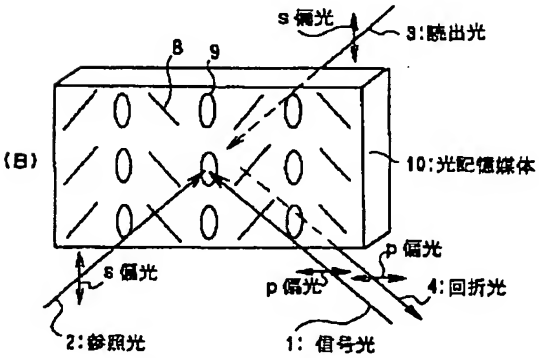
DRAWINGS

[Drawing 1]

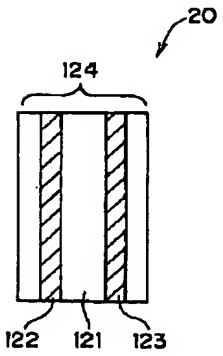


[Drawing 2]

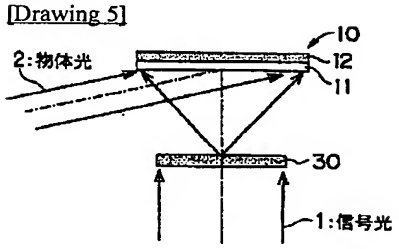




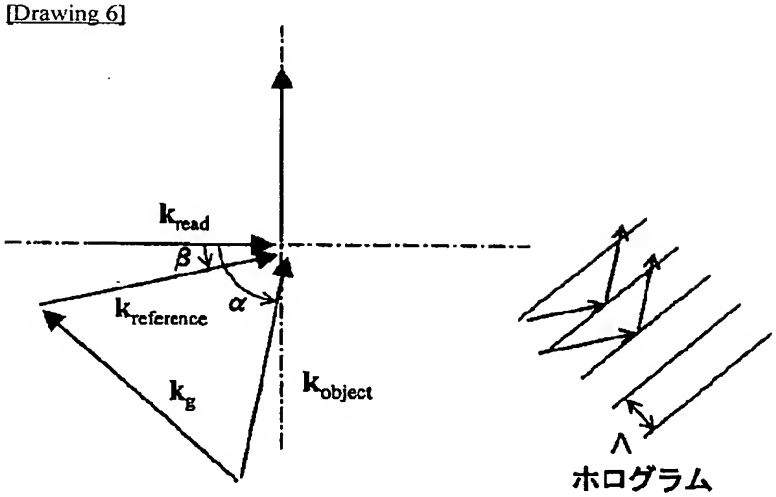
[Drawing 4]



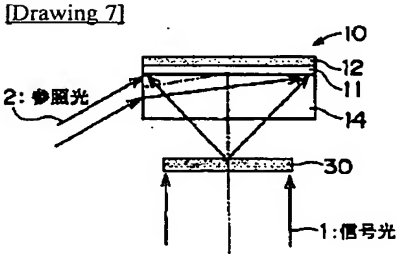
[Drawing 5]



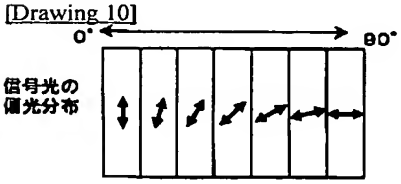
[Drawing 6]



[Drawing 7]

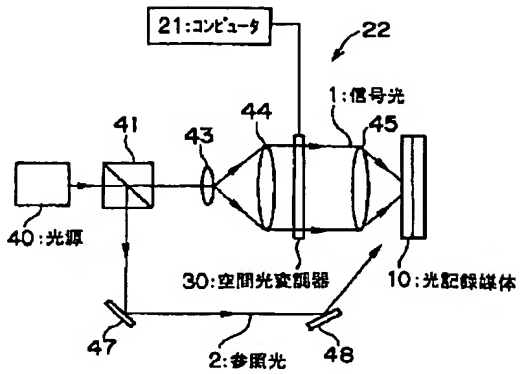


[Drawing 10]

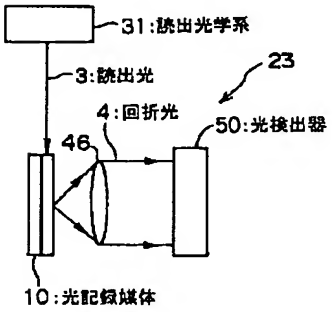


[Drawing 3]

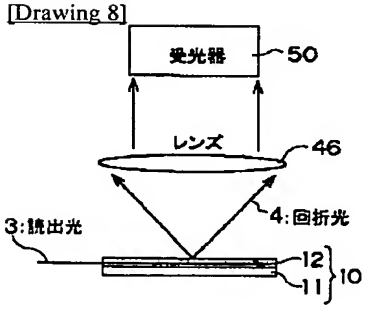
(A)



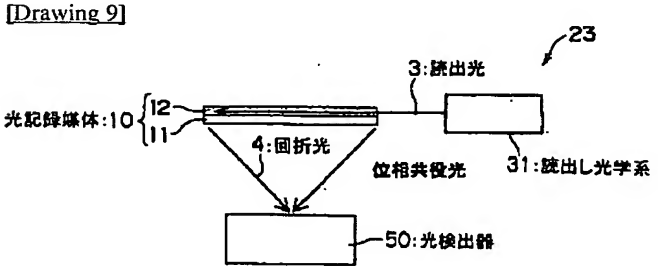
(B)



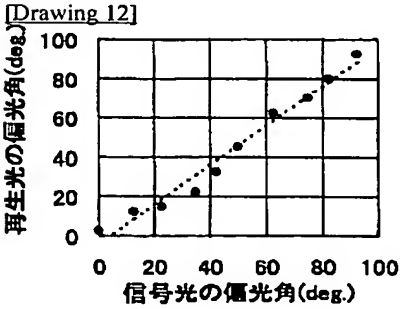
[Drawing 8]



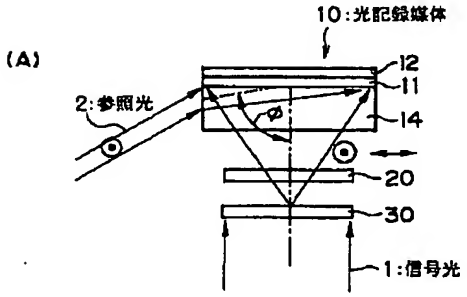
[Drawing 9]

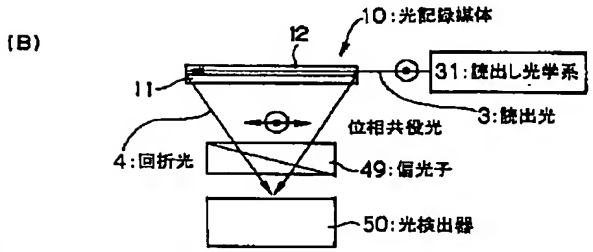


[Drawing 12]

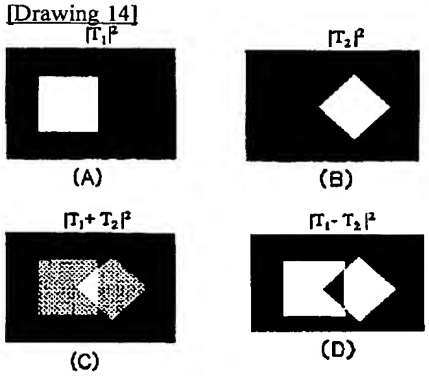


[Drawing 13]

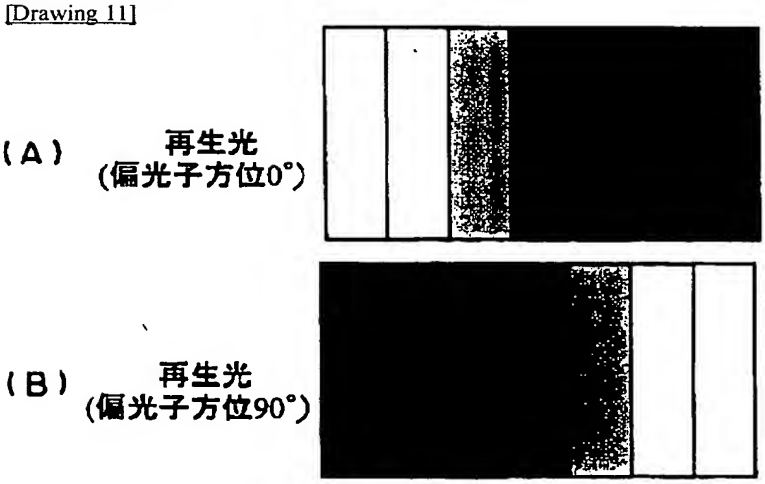




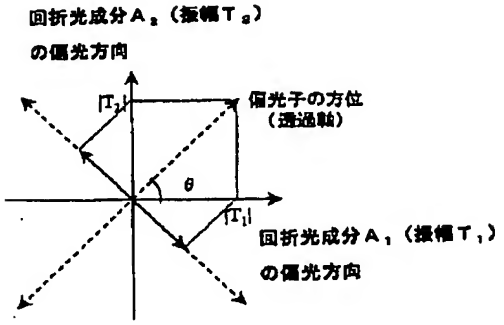
[Drawing 14]



[Drawing 11]



[Drawing 15]



[Translation done.]